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NORTH STAFFORDSHIRE

NATURALISTS' FIELD CLUB.

ADDRESSES, PAPERS, ETC.

CROXDEN ABBEY.

NORTH STAFFORDSHIRE

NATURALISTS' FIELD CLUB.

ANNUAL ADDRESSES, PAPERS,

ETC.

THE LOVE OF NATURE WORKS
AND WARMS THE BOSOM, TILL AT LAST, SUBLIMED
TO RAPTURE AND ENTHUSIASTIC HEAT,
WE FEEL THE PRESENT DEITY, AND TASTE
THE JOY OF GOD TO SEE A HAPPY WORLD.

Thomson.

WITH ILLUSTRATIONS.

HANLEY:
PRINTED FOR THE PUBLICATION COMMITTEE BY WILLIAM TIMMIS.

1875.

PREFACE.

The Publication Committee of the North Staffordshire Naturalists' Field Club have much pleasure in issuing to their fellow-members a selection of Addresses and Papers read before the society, together with special contributions on the Fossil Fauna of the North Staffordshire Coalfield and the Entomology of the district.

The Committee regret that they have not been able to fulfil all the anticipations of the Prospectus. They have in hand two or three Papers which they regard—with the concurrence of the writers, they feel assured—as the nucleus of a second volume, to be published at some future time.

The Committee tender their best thanks to the contributors, to Dr. J. Barnard Davis for the loan of a number of valuable wood engravings, and to Mr. A. A. Bradbury for enriching the volume with an etching of Croxden Abbey.

J. L. C.

Hanley, May, 1875.

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INTRODUCTION.

BY THOMAS W. DALTRY, M.A., F.L.S., HON. SECRETARY.

THE North Staffordshire Naturalists' Field Club was established in the early part of the year 1865, and it has consequently been in existence ten years. In the first Annual Report its object was stated to be "the practical study of natural history in all its branches and the cultivation of a fuller knowledge of the antiquities in the neighbourhood." With this view it was laid down in the rules of the club that there should be five or more field meetings during the year in suitable localities, and that evening meetings should be held during the winter months for the exhibition of specimens and the communication and discussion of any subjects connected with the objects of the club.

At first, the number as well of excursions as of evening meetings fluctuated every year, but as experience was gained in the management and working of the club it was found that the most successful plan was to have seven excursions each season, viz.: one in each month from April to October inclusive (once or twice there has also been a special additional excursion), and four evening meetings held in turn at different towns in the district, the last of which is the annual meeting, by the rules to be held in March, with which the club concludes its year. At this meeting the officers for the ensuing year are appointed and the excursions and evening meetings arranged.

There have thus been held during the ten years of the club's existence seventy-two field meetings or excursions and thirty-five evening meetings. At first, papers were only read at the latter, but of late a custom has grown up of not unfrequently reading *in situ* papers descriptive of the locality visited, generally archæological and historical, but sometimes geological or botanical.

The places visited in each year are as follows, and the notice after each name indicates to which branch of the club's operations the excursion was especially directed :—

1865.

Biddulph	Geology and Botany
Dovedale	Ditto
Congleton and Mow Cop	Botany and Entomology
Trentham	Geology and Botany
Thor's Cavern and Wetton	Ditto
Froghall and Cauldon Low	Ditto
Tutbury and Rolleston	Archæology and Botany

1866.

Heleigh Castle	Botany and Archæology
Hanbury and Bagot's Park	Botany and Geology
Stone and Oulton	Botany and Entomology
Beaudesert and Mavesyn Ridware	Archæology and Botany
Cloud End and Congleton	Botany and Entomology
The Wrekin and Wroxeter (Uriconium)	Archæology and Botany
Dovedale	Geology and Botany
Froghall and Cauldon Low	Ditto
Dudley	Geology

1867.

Froghall	Geology
Madeley and Heleigh Castle	Botany

Cannock Chase	Geology
Chartley	Botany

1868.

Maer Church and Woods	Archæology and Botany
Croxden Abbey	Ditto
Longton Hall and Cocknage	Botany and Entomology
Leek and the Roches	Geology and Botany
Wybunbury	Botany
Oakamoor and Cotton Woods	Botany and Entomology
Hanley Deep Pit	Geology

1869.

Macclesfield and Kerridge	Geology and Botany
Dovedale	Ditto
Swithamley and Ludchurch	Ditto
Thorney Edge and Wetley Rocks	Botany and Entomology
Wooton and the Weaver Hills	Botany and History
Joiner's Square Marl Pit	Geology
Lichfield	Archæology
Marston Old Salt Mine	Geology

1870.

Eccleshall	Archæology
Hawkestone	Botany
Wetton	Geology and Botany
Cheddleton and Combes Valley	Archæology and Geology
Wenlock and Buildwas Abbeys	Archæology and Botany
Beeston Castle and Peckforton	Ditto
Shrewsbury	Archæology

1871.

Moreton Old Hall and Astbury Church	Archæology
Combermere	Botany and Entomology
Dovedale	Geology and Botany
Hawkestone	Archæology and Botany
Chartley	Botany and History
Rudyard	Botany and Entomology

Dudley - - - - - - - - -	Geology
1872.	
Gawsworth and Marton - -	Archæology and Entomology
Trentham - - - - - - -	Geology and Botany
Colwyn and Little Orme's Head - - - - -	Botany
Boscobel, Whiteladies, and Tong - - - -	Archæology
Lilleshall Abbey - - - -	Archæology and Geology
Swithamley - - - - -	Botany and Entomology
Battlefield Church and Haughmond Abbey - - - - -	History and Archæology
Ashby-de-la-Zouch - - - -	Ditto
1873.	
New Brighton - - - - -	Entomology and Botany
Croxden Abbey - - - -	Archæology and Botany
Pickwood - - - - - -	Botany and Entomology
Rushton and Rudyard - -	Archæology and Entomology
Mow Cop and Biddulph - - - -	Geology and Botany
Welshampton and Ellesmere - - - - -	Archæology
Hanbury and Tutbury - - - - - -	Ditto
1874.	
Leigh, Checkley, and Draycott Churches - -	Archæology
Elford and Lichfield - - - - - - -	Ditto
Upper Dove Valley and Pike Pool	Botany and Entomology
Bagot's Park - - - - - - - -	Geology
Llanberis, Snowdon, and Bettws-y-Coed - -	Ditto
The Wrekin and Wroxeter - -	Archæology and Geology
Marston Old Salt Mine - - - - - -	Geology

The papers which have been read before the club have been the following :—

1865—6.

1. "On the power that certain Rotifers have of fixing themselves by a thread." Mr. R. GARNER, F.L.S.
2. "On the Fossil Fishes of the North Staffordshire Coalfield." Mr. J. WARD, F.G.S.

3. "On Peat Mosses, and upon the Natural History, etc., of Dane's Moss, near Macclesfield." Mr. J. D. Sainter, F.G.S.

1866—67.

4. "On the Ironstone of the Churnet Valley." Mr. T. Wardle, F.G.S.
5. "On the Origin of the Churnet Valley." Mr. J. E. Davis.
6. "On the Gravel Pits at Trentham." Mr. W. Molyneux, F.G.S.
7. "Notes on the Natural History of Weymouth." Mr. J. Yates.

1867—8.

8. "On the Mistletoe." The Rev. Thos. W. Daltry, M.A., F.L.S.
9. "On the Alum Bay Leaf-Bed in the Isle of Wight." The Right Rev. Dr. S. T. Nevill, M.A., F.L.S.
10. "Notes on Connemara." Mr. Molyneux.
11. "On a Curiosity in Natural History," the said Curiosity being a monstrous Blackbird's Egg, which on being broken was found to contain a smaller perfect one. Mr. Yates.

1868—9.

12. "The Geology of the Roches and the Goldsitch Coal Bed." Mr. Wardle.
13. "Mountains, their Forms, Uses, and Products." Mr. W. Spooner.

1869—70.

14. "On the Life of Rousseau, writer and botanist." The Rev. J. S. Broad, M.A.
15. "On a Fossil Tree in the Marl Pit at Joiner's Square, Hanley." Mr. J. E. Davis.
16. "On the Fossil Trees in the Marl Pit at Hanley." Mr. Ward.

17. "On the Manx Fishermen." Mr. GARNER.
18. "On some Discoveries in a cleft in the Mountain Limestone at Narrowdale, near Alstonefield." Mr. S. CARRINGTON.
19. "Some facts in the local history of Leek." Mr. J. SLEIGH.
20. "On the Rhætic beds of Needwood Forest." Mr. MOLYNEUX.
21. First Annual Address. Mr. GARNER.

1870—71.

22. "Eccleshall and its neighbourhood." Mr. YATES.
23. "Wenlock and Buildwas Abbeys." The Rev. J. S. BROAD.
24. "Beeston Castle." The Rev. J. S. BROAD.
25. "On some Fossil Remains of Reptiles in the North Staffordshire Coal Field." Mr. WARD.
26. "On the Absence of Waterfalls in North Staffordshire." Mr. J. E. DAVIS.
27. "On Old Newcastle." The Rev. J. S. BROAD.
28. "On some recent improvements in the Methods of Microscopical Research." Dr. ROSS.
29. Annual Address—"The purpose or *role* of Minute Organisms during the past and present epochs of the Globe." Dr. ARLIDGE.

1871—72.

30. "Chartley Park and Castle." The Rev. J. S. BROAD.
31. "On the Geological Features of the Wren's Nest, near Dudley." Mr. W. MADELEY.
32. "On the Poetry of Natural History." The Rev. J. S. BROAD.
33. "On the Lepidoptera of North Staffordshire." The Rev. THOS. W. DALTRY.
34. "Our Place in the Universe." Mr. H. W. HOLLIS, F.R.A.S.

35. Annual Address. The Rev. J. S. Broad.

1872—73.

36. "On the Bunter Gravel Beds." Mr. Molyneux.
37. "Boscobel, Whiteladies, and Tong Church." The Rev. J. S. Broad.
38. "On the Geology of Lilleshall and neighbourhood." Mr. Molyneux.
39. "On the Historical Associations of Battlefield and Haughmond Abbey." The Rev. J. S. Broad.
40. "Natural History of Llandudno." Mr. Yates.
41. "On Tokens." Mr. A. Leech.
42. "On Crags and Cairns." Mr. Garner.
43. "On the Interments of Primitive Man." Dr. J. Barnard Davis, F.R.S., F.A.S.
44. "On Glaciers." Mr. H. Woodall.
45. Annual Address—"On Limestone: its Occurrence, Nature, and Origin." Mr. Wardle.

1873—74.

46. "Croxden Abbey." Mr. Lynam.
47. "On the Flora of Rudyard and Neighbourhood." Mr. W. S. Brough.
48. "On the Geology of Mow Cop, Congleton Edge, and the surrounding district." Mr. Sainter.
49. "Tutbury: its Castle and Associations." The Rev. J. S. Broad.
50. "On the Literature of Botany." Mr. W. S. Brough.
51. "On some Lepidoptera new to the district, taken in 1874." The Rev. Thos. W. Daltry.
52. "An Outline of the History of English Mediæval Architecture, illustrated by Staffordshire Examples." Mr. Lynam.
53. Annual Address—"Observations in Natural History during a Month's Tour through France and Italy." Mr. Yates.

1874—75.

54. "On the Geology of Needwood Forest." Mr. MOLYNEUX.
55. "On the Extinct Glaciers of Snowdon." Mr. J. L. CHERRY.
56. "On Uriconium." The Rev. J. S. BROAD.
57. "On Salt." Mr. WARDLE.
58. "On Ancient Church Bells in Staffordshire." Mr. LYNAM.
59. "On the Structural Features of Plants in relation to their uses in the Arts and in Medicine." Dr. ARLIDGE.
60. Annual Address—"On the Sepulchral Monuments of Staffordshire." Mr. LYNAM.

Besides these written papers, addresses have been given by members of the club and others upon many curious and interesting subjects of natural history, etc. Thus, Mr. Garner has discoursed on the natural history of the immediate neighbourhood of Stoke-upon-Trent and of the Upper Trent Valley, on the birds of Leek and its neighbourhood, on the History of Dudley Castle, and on the manner in which the moult of certain Crustaceæ, *e.g.*, crabs, lobsters, &c., is performed He has exhibited and commented upon a white-fruited variety of the common bilberry, Vaccinium Myrtillus, found at Swynnerton ; a hybrid between the bilberry and cowberry, V. Vitis-idæa, found at Maer ; the Hutchinsia Petræa, from Dovedale, one of the least of flowering plants ; the House Ant, Diplorhopterum Molesta ; the Euplectella Aspergillum from the Philippine Islands ; and the curious mechanism of the dorsal and fin bones of the Chætodon Anthriticus. Dr. Nevill, F.L.S., Bishop of Dunedin, has addressed the club on the true place of the Hydrachne Globulus, and on the surface geology of Otago, New Zealand. The Rev. H. G.

de Bunsen has related the history of Lilleshall Abbey. Mr. J. Plant, F.G.S., of Manchester, has spoken on the geology of Rudyard and neighbourhood, and Mr. Leo W. Grindon, of the Manchester Naturalists' Field Club, on the botany of Mow Cop and Congleton Edge. Mr. W. Challinor has told of "Some interesting features in the history of Leek," and Mr. W. S. Brough has explained its flora. Mr. W. Jones has read an extract from the Municipal Archives of Stafford relative to the visit of Queen Elizabeth to Stafford on her way from Chartley in 1575, and Mr. G. A. Slater has brought under the notice of the club the curious stalactite commonly known as Buxton oak, a variety of sulphate of barium.

These are, after all, but a few of the many interesting subjects which have from time to time been brought before the club; but at any rate they are sufficient to show that good work is being done by many of its members, and they will serve to introduce this volume of selections, which comes as a fitting close to its first ten years' existence, and an earnest, let us hope, of renewed vigour and activity.

ANNUAL ADDRESS, 1870.

BY ROBERT GARNER, F.L.S.

I THINK at one of our late meetings I must have convinced you that I was ready to fight as an earnest soldier in the ranks of science, and natural science in particular. I am not disposed to admit that natural history, in any of its branches, is but an amusement, or at most an unimportant study. And on this point I will descant a little more. I understand some of our friends call us "grub-hunters." Well, let it be so; but I have been inclined to retort,—What then are *you*, ever toiling, burrowing, spinning, after pence? *You* must be the real thing itself. We were lately, *apropos* of grubs, handsomely treated by our Leek friends, but in one thing I find fault with them. Their prosperity depends upon grubs; their daily bread. I might almost indulge in a pun, but I will not. At the present moment, probably, in the Far East, millions of grubs or caterpillars are at work for them. Nearer home, in the plains of Lombardy, or of South France, as summer comes in, millions will be at work there, fed by thousands of country people, till they have spun their cocoons, which are brought to our Moorland town and there unravelled and re-spun, ready again to employ and enrich other districts and other people.

Grubs, then, are important creatures, and one of our Moorland members ought to illuminate us with the history of the silkworm—of the new one, the ailanthus, exciting

much interest—not forgetting that disease which has produced so much alarm in the rearers. Two or three years back the turnips in every field were seen to droop in an extraordinary manner in the month of August. If you noticed a field, you would find that every turnip was affected. The loss even in our own country must have amounted to thousands of pounds. Upon examination, it was found that every turnip near its crown was being devoured by a grub, the larva, Mr. Earl thinks, of an agrotis. By scraping away the soil, five or six of these creatures were found at every bulb, eating great holes in it. So easily were they found, that a few boys and girls collected pecks of them in a day or two, quite clearing the roots of these destroyers, and saving the crop of a whole field. A few days after, to assist us, rain fell ; and a vigorous growth is the best help of the plants to overcome such devastations, as is also seen with the turnip flea (a beetle be it observed). What was curious, further depredations being prevented by the enemy being sought out and destroyed, the larger holes became cicatrised, and the turnips were a tolerably fair sample after all. I consider that I saved them by attention to these grubs.

I might take an instance from the vegetable kingdom of a very humble natural product being of great importance, (cotton, the flocculent bed of the seeds in the pericarp of the gossipium), and spin as long a yarn as in the case of the silkworm. The gist of my observations is that the subjects of our studies and the studies themselves are not to be despised. No man can excel in agriculture, in gardening, in medicine, without a knowledge of certain departments of natural history. The farmer may well study insects and their depredations, the breeder Darwin's work on the origin of species, the horticulturist his later work

on the fertilization of plants, and it may be said that the medical man who does not possess a general knowledge of the laws regulating the different divisions of organized beings must have a very limited horizon to his view.

I maintain that it is a duty to observe the productions of nature. "The works of the Lord are great, sought out of all them who have pleasure therein." Show me the man in whose soul no admiration for natural objects has ever been cultivated, and I would say, if called upon, "Friend, thou may'st be a great politician, or man of business, as the case may be, but thou art but imperfectly developed in thy intellectual faculties after all. Thy dominant thoughts, and habits, and faculties have absorbed too much the gentler ones, on which depends a love of nature, of the fine arts, of music, of poetry, much, in fact, of the most innocent enjoyment of life." Such individuals may well be distinguished as belonging to the *nil admirari* school. This brings me to the concluding part of my subject.

In our geological speculations we have enjoyed a very broad field of discussion, without our clerical friends expressing any fear of the result, or endeavouring to stop the spirit of free enquiry. This, you will agree with me, redounds to their honour. Let us, then, be thankful, and, at the same time, let us be anxious not to abuse our liberty. I trust we have not already done so. You have certainly heard it hinted by the geologists that our earth is of immense antiquity, that man must have existed in it for a much longer period than has been supposed, that our planet is but one out of many, possibly all inhabited, that our sun and solar system is but a speck in the vast expanse of space. This has not shocked our feelings, but

led us, I believe, to bow with reverence before the great Creator, the God, not of one small sphere alone, or one short space of time, but of spheres inconceivable and of time untold.

There is an error in the study of nature which, I am sorry to admit, preponderates at the present day, founded, however, on modes of reasoning which in some respects may have kept us in the right path, yet, carried to extremes, betoken rather a poverty of the understanding. One of the beautiful features in the study of natural history is —that we are irresistibly led from the survey of the nice adaptation of parts in plants and animals to look "from nature up to nature's God." This is wrong according to the school in question; we have no right to mount so high; we must discard final causes. The author of a folio volume on the "shoulder girdle" of the vertebrata ends by observing, "Not only is a teleological explanation (that is, a consideration of the design) a mere impertinence in a morphological work; it is also a biassing hindrance— a pretty golden ball that diverts the racer from his course." Say perhaps a golden thread that we should trace in our dry researches, or a source of present return in a prolonged undertaking, of which the eventual profit must be far distant. I do not hold with this school on the above question, nor in their discarding of the reduction of variations, or new appearances in structures, to an antetype exemplar, what the anatomist in question calls the "high *priori*" road. The heart certainly presents the characteristics of a beautiful hydraulic machine, the eye all the dioptric contrivances of an optical instrument; yet this originates from—what do they say?—from the "nature of things," from the "law of development," from "organic force or growth," from the "vital force," or even from

physical laws; we must mount no higher. We will not brand this class of philosophers with the title of atheists, but say they are of a peculiar frame of mind. No doubt they are generally believers in the existence of an overruling power. Dr. S. Clarke, who has probably written on the being and attributes of God as well as any man, admits (Discourse, 1749, p. 159) that it may be held that infinite wisdom, foresight, and unerring design originally so ordered, disposed, and adapted all the springs and series of future necessary and unintelligent causes, that, without the immediate interposition of almighty power upon every particular occasion, they should regularly, by virtue of that original disposition, have produced effects worthy to proceed from the direction and government of infinite wisdom.

At the same time let us not give up our belief that we can trace the finger of a Designer and Creator in the objects around us. The effort to discover the uses of parts (necessarily in our opinion implying design) has led to more discoveries in anatomy and natural history than any other principle of research. This caused Harvey to discover the circulation of the blood. Ray and Derham, Paley, and the authors of the Bridgewater Treatises have developed this mode of reasoning, and Cuvier, Hunter, and Owen have been content to trace design, and to discover. Paley instances the curious mechanism of the superior oblique muscle of the human eye as a plain and unmistakable instance of a simple but thoroughly artificial contrivance, sufficiently mechanical to convince any one that it originates in a design. With respect to the eye, I once met with an instance of structure for a purpose, which I call design, that is very remarkable, but of a miniature description, in the cirripides, a class of animals

half-shelled mollusca, half-jointed crustacea. They are more or less fixed by a pedicle, but are sensible of light, as it is easy to convince oneself. You will find in all the descriptions of these animals that they have an eye, but buried in the substance of the body, and quite covered by the thick, horny, opaque covering. If this were true, there would be no use in the little organ, but I found, in dissection, that exactly over the eye is a small clear, translucent, diamond-shaped spot in the integument, through which the little black eyespot can be seen, and through which the light penetrates to it. Other anatomists must have passed it over as only an accidental spot in the integument.

An older naturalist than Ray or Derham traced up organization to the great originator. "That His name is great, His wondrous works declare." "O Lord, how manifold are thy works! In wisdom thou hast made them all. The earth is full of thy riches. So is the great and wide sea, wherein are things creeping innumerable, both small and great beasts. There go the ships—(there go the nautili);—there is that leviathan, whom thou hast made to play therein. These wait all upon thee, that thou mayest give them their meat in due season." I prefer my friend Mr. Broad's conjectural reading of nautili for ships. Ships are not the work of God, nor can they be said to be fed by or to wait upon God, whilst nautili, or little ship-formed molluscs, supposed to have given the first idea of ships, agree with the context; and the antithesis between the huge whale or leviathan and the diminutive animate skiff is striking. The reading has much struck some good judges. Professor Owen is delighted with it.

Ours is an age when old-established opinions receive

rude shocks. A quarter of a century back a man would have been laughed at who professed a belief that living beings could originate from dead organic matter, independently of germs derived from the air or other medium. Now the doctrine of *omnis ex ovo* has been much discussed, especially in France, by M. Pouchet on the unorthodox side and M. Pasteur on the other. In England several men of note, Owen for instance, have sided with the former. On the other hand, you know that Professor Tyndall has beautifully shown how the atmosphere swarms with organic particles. I have examined the bacteria and monades in infusions of hay, ergot of rye, bread, and bruised oats at stated periods, and under the same circumstances. Animalcules of different appearance in each case are seen to abound, so that if the germs are derived from the air it must swarm with those of all these kinds, as well as with the germs of all others that can originate from an exposure of any infusion or decaying matter to the air. Here again we may, if we choose, believe in the doctrine of spontaneous generation; nay, deny the doctrine of a special creation of animals and vegetables, even if we are literalists, and thereto it is sufficient to refer to the 1st chapter of Genesis. Earth and water "brought forth" vegetables and animals by the divine fiat. With man it was not so. He, agreeable to what Mr. Wallace and others on different grounds have concluded, appears not to have descended from a lower form, but to be an especial creation. These are deep subjects, and I am diffident in expressing an opinion with respect to them.

We have already in our past meetings had opportunities of referring to the doctrine that from the beginning the earth has undergone a continuous series of changes, much the same and not more violent than we ourselves witness

at the present epoch, and that geological phenomena are solely owing to these slow changes; and another doctrine, that of Mr. Spencer, is, that a process of evolution is going on throughout the universe in all things; in ourselves, our bodies and minds; in morals and politics, in organized beings, in heavenly bodies. Protoplasm becomes differentiated and integrated into organic forms, and so with the pabulum which generates animalcules in the infusions, even up to the diffused matter of nebulæ giving origin to planets and the other heavenly orbs. I presume that, as St. Paul tells the Romans, the phenomena which we, as naturalists, are led to contemplate—the beauty, variety, order, and conformation of organic beings; their means of increase, sustenance, defence, and so on—constitute the great argument for the existence of the Good Father of us all.

But let us admit that other men may believe, without being atheists, that dead matter may under certain circumstances be vivified to the lower forms of animal life—that the higher becomes differentiated and evolved from the more simple; or, with Darwin, that species are produced by the law of selection, forms becoming extinct by being placed at disadvantage in the struggle for existence. This we may concede without necessarily agreeing with the doctrines. Of none am I myself convinced. A star-fish, with me, is an animal designed, morphologically or externally, upon a totally different plan from that of an insect or a mammal, and therefore no evolution nor natural selection could change it into either; and with me a species remains for ever a species—a reality, not a mere abstraction of the mind.

There are other important doctrines with respect to

which religion and science are certainly not in antagonism, though we may not be able to say that any light is cast upon them by science. The immortality of the soul, the existence of a future state, rewards and punishments to come, and the prevalence of evil in the world, can neither be proved, nor disproved, nor accounted for by science; they are only known to us by revelation. In fact, revelation is the making known to us of things which we are incapable of ascertaining by other means; therefore it borrows little light from the knowledge of nature. All that we may expect is that the two shall not clash. Whilst we cannot but agree with the geologist as to the vast antiquity of the earth, we may more reasonably demur in respect to the high antiquity attributed to man. How is it that he could exist for so many ages and yet have produced nothing more than a few rude flint weapons, whilst, on the contrary, in the last few millennia he has achieved so much? This is somewhat incredible.

Take a liberal and spiritual view of the first part of Genesis, and I think geologists and theologians need not quarrel. We have there a sublime production, written by the man who was chosen by God to be the leader, law-giver, and religious instructor of the chosen race; the oldest of writings probably, commencing the holy and approved archives of religion, yet apparently partly compiled from earlier sources, written or traditional, primarily at least intended for the instruction of a nascent and still rude race. Sublime, and holy, and venerable as it is, I should not be disposed to regard it in the same light as the first chapter of St. John, for instance, the writer of which, who wrote especially for us, had evidently the first of Genesis in his mind. Of this I believe every word as it stands; indeed, this gospel has always been admitted by

the Christian Church, embodying though it does the greatest mysteries and miracles, the incarnation and the creation of the world by or through Christ, whichever the preposition may mean. St. John tells us in fact what he had heard, what he had seen with his eyes, what he had looked upon, and his hands had handled, of the Word of Life. The Mosaic account tells us of the creation by God alone, the late appearance of man upon the earth, the institution of the Sabbath—gives us an explanation of the existence of evil and the origin of nations and languages.

With all this science is not antagonistic, but rather tallies. We perhaps may also say that we have apparently a shadowing forth of geological epochs, and of the succession of life in the account of the six days' work, but here let us stop and leave the rest for time and research to clear up. Where science and religion seem to clash, I should say abide by what your senses and your reason clearly show. So far you cannot go wrong; but it by no means follows that you must renounce revelation; only that you enquire whether its written records necessarily imply what you have supposed, or what it has generally been supposed that they imply. A knowledge of natural history has strengthened my confidence in the Bible and revelation in one simple and pleasing manner. A doubt may flash across a man's mind, Were the books of the Bible really written at the times and in the countries when and where they profess to have been? On some points, and with respect to some plants or animals, there may be obscurities, but upon the whole we may say the books are in this respect genuine and authentic: the natural objects described or mentioned, animal or vegetable, even the diseases alluded to, both

as regards Palestine and Egypt, have evidently been described from real observation on the spot. Thus, as far as our science goes, we are assured that the holy books will lose none of their dignity by being examined with a critical eye, but in fact the reverse.

ANNUAL ADDRESS, 1871.

BY J. T. ARLIDGE, M.D. (LOND.)

ACCEPTING it as a rule of the club, that the outgoing President do, at the annual general meeting, deliver something in the shape of an Address, I shall make no apology in asking your courteous attention to the remarks I propose to place before you.

The subject matter of the discourse is left to the discretion of the speaker; yet, at the same time, it is his duty to make it relevant to the studies of the members, to remember the particular occasion on which he addresses you, and to endeavour to point out something conducive to the interests of the club.

My very learned predecessor in office, our most valued friend Mr. Garner, took occasion in his address last spring to insist upon the excellencies of natural history research, and to enlarge upon the teachings of natural science as illustrative of the great truths of natural theology. Were I willing to follow in the same track I should find little to glean in a field so fully preoccupied by him.

Other matter to base a discourse upon would have been the proceedings of the club during the past year, but the

Report of the Committee, by detailing the work done in excursions and meetings, cuts away this basis from under me so far as the narration of events and of particular discoveries is concerned. Nevertheless, I consider some scope is left for a general survey of the operations of the club in the past and of those that may be undertaken in the future. Some such general remarks I now propose to make, and after ending them, I shall attempt a short discourse on a special question in natural history science, which I trust will not be without interest to you all.

I will begin by putting a question, viz. :—Is this club doing all it can towards fulfilling the purposes contemplated by its formation? Or, to put it in another shape, are there no forms of improvement practicable in the constitution and modes of action of the club? As an individual I must confess to the conviction that there is room for considerable improvement, and that, as an association for promoting natural history study, we are not doing all that can be accomplished by us for that end. Of the two classes of the club's operations I think the winter evening meetings to be the more successful and useful. The meetings have been well attended, and the gathering together of so many people with the definite object of bringing under their notice natural history facts and theories by means of papers, discussions, and specimens, cannot fail to be of advantage in kindling amongst some an interest in one or other department of natural history, or otherwise in some questions of archæology.

Such gatherings I hold to have contributed more to the advancement of the objects contemplated by the club than have the field excursions themselves, although these latter, theoretically at least, constitute its primary purpose, and

the winter evening meetings are secondary and supplementary to them. If you agree with me in these views, the question arises, how can the excursions be made more effectual? There are now above 200 members, and at some excursions nearly a hundred have been present. The admission into the club may be assumed as indicative on the part of those admitted of interest in one or more of the branches of science the association is formed to promote. But though this inference be correct, and the presence of the members at excursions be taken as further evidence of the same, yet the actual results of the excursions, and the circumstances patent to all who have joined in the excursions, show that their full and legitimate benefits have not been secured. And I venture to assume that few members will dissent from the opinion that the excursions have largely assumed the character of pleasurable jauntings in the country and cheerful pic-nics. Now I am one of the last to wish to chase away pleasure and cheerfulness from our gatherings out of doors, but I want to combine those good qualities with a larger share of real observation and interpretation of the works of nature, and likewise those of art included within the recognised scope of the club's purposes. As professed students of nature we should go forth into the fields under another character than that of mere holiday excursionists.

You will ask, How are matters to be mended? An answer involves an enquiry how it comes to pass that the scientific character of the excursions is so far lost sight of. One explanation at once occurs, viz:—that although members have exhibited their interest in the purposes contemplated by the club, their information in natural history and archæology is so imperfect that they cannot of themselves follow out observations, or seize upon those points of

interest which the localities visited may possess. In other words, they need instruction. They require the presence of some better informed naturalist to call their attention to objects and to interpret phenomena for them. The trudging along country lanes and across fields, even in the company of distinguished naturalists, is not edifying unless those *elite* individuals condescend to be communicative, and to act as showmen and teachers for the occasion. At almost every excursion something is done in the way of instruction by the reading of a paper, and mostly the papers have been of late rather of archæological and historical than of natural history interest. It is well that this has been the case, and all those who have been present at their reading will concur in valuing those papers and in thanking their authors. It is well, I say, that the papers read have possessed that character, for they were more fully and largely appreciated than purely natural history papers would have been.

This remark leads me on by way of explanation of it to say that natural science must be entered upon from its rudiments. The researches of its devotees cannot be appreciated by the uninitiated. Each branch of natural history has, so to speak, an alphabet of its own, and no advance can be made in it until this alphabet is mastered. It is the absence of this rudimentary knowledge on the part of many members that, in my opinion, causes the excursions to degenerate into mere country walks. The same want likewise lessens materially the interest and value of our winter evening meetings. What information or what pleasure can be derived from a paper on botany, or on geology, or on palæontology, or on archæology, on the part of those to whom the terms used in description are equal to so much Chinese in comprehensibility? Ladies and gentlemen, you will from what I have said apprehend

more or less clearly what I am about to say. The sum and substance of that is, that the club must become more than heretofore an instrument of instruction. It may so become by improved organization and arrangements of the excursions, by amendments in the proceedings of the evening meetings, and lastly, by supplementary measures under the auspices of the club. More in the way of demonstration may be attempted both in the case of excursions and of meetings. In the excursions it would be well to divide the party among several leaders, each leader being able and willing to act as a teacher in one or other department of natural science. We have among ourselves men well versed in these departments, and I am sure they will be willing to diffuse the information they possess.

Moreover, it is desirable to prepare the members beforehand to take part in the scientific work that ought to be the real end and aim of every excursion, and I would put forward the suggestion that something in the way of lectures, or at least of demonstrations, might be carried out in connexion with the club and supplementary to it. We have members qualified to give instruction in botany, in zoology (including ornithology and entomology), in geology and palæontology, and also in archæology, and I believe some plan might be devised whereby opportunity could be afforded to those members to convey the instruction.

I must crave your forgiveness for having so long occupied your time with the preceding remarks on the working of the club. How far my suggestions may be likely to improve and advance the operations of the club I leave to your decision; but I am penetrated with the conviction that some measures are needed to give increased

energy and usefulness to the club, considered as an association specially instituted for the promotion of natural history.

Ladies and gentlemen, having read you a lecture on your duties and obligations, I will now take up a question in natural history which is of interest, and I trust will be found so by you, notwithstanding the imperfections with which it may be placed before you. I propose to make the subject of this address the purpose or *role* of minute organisms during the past and present epochs of the globe.

The minute organisms intended are those living creatures, whether belonging to the animal or to the vegetable kingdom, which are of more or less minute dimensions and simple in organization. Among such organisms I reckon protozoa, protophyta, phytozoa, and zoophytes. The influence exerted by these may be viewed in reference to past and present ages, and both in respect to man and the earth he inhabits.

Time was, and not so very long since, when zoophytes, as represented by polypes, sponges, and corals, were regarded as the lowest examples of life and of vital organization; and it was debated ground as to whether the organisms referred to those groups were of animal or of plant nature. The discussion of this point led to a more accurate separation and classification of such beings, and the result has been to establish distinctly the peculiar features of animal and of vegetable life in reference to them, and to exclude certain forms from the animal kingdom, such as the corallines, which had previously been located in it.

But these, to our forefathers primitive and minutest forms

of life, have, since the discovery and improvement of the microscope, had to yield this estimate to a whole world of beings, animal and vegetable in nature, of so much minuter character that the zoophytes are veritable giants or even mountains in respects to them. These smallest organisms were at first spoken of collectively as infusoria, and a like warfare prevailed, as in the instance of the corals and sponges, on the question as to whether they were plants or animals, and as to which were plants and which animals. This contest indeed is still undecided with respect to many among them, and it is doubtful whether, with regard to some of them, it can ever be decided. However, the discussions that have prevailed have resulted in the determination of the real nature of a large proportion; and naturalists concur in recognising two great classes—the protozoa and the protophyta—i.e. primordial animals and primordial plants. The still doubtful beings are arranged as phytozoa, or plant-animals.

The diffusion of microscopic organisms has been especially remarked in water, and the teeming of a drop of pond water with life is a phenomenon calculated to arrest the attention of even the casual observer. But water is not the only medium in which they abound, for although the more definite and larger forms are to be found in it, yet we now know that the surface soil and the air also abound in organic germs.

Prof. Tyndall's expeniments and observations, as recounted in his Lecture on Dust and Disease, take rank among those things calculated to arrest the attention of every thinking individual. Many of you, I doubt not, have read that lecture, either in its entirety, or in abstract as it appeared in the *Times* newspaper and in several journals.

Nothing could convey a clearer conception of the extreme divisibility and diffusibility of organic matter than the record furnished by that eminent philosopher of his experiments and their results. He dealt with particles that would be completely hidden from the highest powers of the microscope, and he was able to prove that such particles were not of inorganic or mineral character, but of organic nature; that is, they were either complete organisms in themselves or had formed part of living beings of some sort or other.

The diffusion of such organic matter through every portion of the atmosphere struck Dr. Tyndall, as it would any other individual, as offering some explanation of the propagation of disease by infection and contagion. In the invisible cloud of organic particles might well lurk germs of disease, whether particles of diseased matter previously separated or actual germs,—living particles endowed with powers of reproduction and capable of setting up diseased action in any favourable soil furnished by animal or plant.

That epidemic and some other diseases may be propagated by germs was indeed no new theory advanced by Tyndall. It is one of much older date; but Tyndall's experiments showed us that we need not be astonished at the circumstance that diseased germs have not been demonstrated. They, in fact, proved that such germs may well evade the most penetrating powers of the microscope, and only become cognizant to us in the exercise of their unwelcome operation as inducers of disease.

The hypothesis of the generation of diseased action by the agency of definite minute organisms has taken wide hold on the medical profession, and several observers have

busied themselves in endeavours to determine the precise form of organic being concerned in the production and dissemination of various diseases, and foremost among these of cholera; but I must confess that, to my mind, these attempts at identification of the offending particles have not succeeded. However, even admitting such failure, the hypothesis of the agency of minute germs in the propagation of disease may still be upheld.

References to authorities and quotations on this question would be out of place here, and so I proceed to remark, that the notion of the direct relation between disease and organic germs of disease is favoured by the analogy of admitted facts. Fermentation and putrefaction, although in general aspect chemical processes, are certainly associated with the presence of definite organisms in the matters undergoing those processes: moreover, there are certain diseases of the skin and of the hair dependent upon the introduction and growth of forms of vegetable life.

The illustrations I have borrowed from medical literature of the part played by the minutest forms of life in the economy of our race, and not I may add of that only, but also in that of all other animals and likewise of plants, might require apology, as being of too professional a character, were they not so much to the purpose. However, I will now briefly notice the influence of the microscopic denizens of water in their relation to the processess of nature now obtaining, as well as to those prevailing in past time.

True it is that "death and decay in all around we see," but nevertheless they eventuate in new life. Animal life exists as a posterior event to vegetable life and is

dependent upon it for its continuance; for animal life cannot maintain itself directly on inorganic or mineral matter, but on that matter by the medium of the vegetable creation, which has the power of transmuting mere brute matter into organized. And although in creation there is a prodigality of life, such relations obtain between animals and plants of all grades as to prevent, to the greatest possible extent, the degradation of the once vitalized material, whether animal or vegetable, into an inorganic or mineral shape.

When solution and disintegration have proceeded in a mass of organized material which has escaped utilization by some higher grade of life, to the uttermost point short of decomposition into its chemical elements, its salts and gases, the microscopic beings, which have of old been collectively described as infusoria, come upon the scene and rescue the particles from the impending retrograde metamorphosis. The drop of water that holds organic matter in ever so small amount in suspension has its miscroscopic inhabitants, carrying on in the extremest simplicity most of the functions of life possessed by the higher orders of creation. Their range in size is as great as, or greater than, that among animals cognizant to ordinary vision. The larger prey upon the smaller, and these upon those minutest germs and particles of organic matter to which I have alluded. At the same time the drop of water is a laboratory in which organic matter is being *de novo* built up from inorganic elements. It has within it a vegetable creation of wide diversity in size and appearance, and withal of much beauty, which draws from it the material necessary to its development. In the observation of these minutest forms of life we tread on the verge of creative energy in its greatest simplicity. We

arrive at a point where the senses fail us, and only inductive inferences, in which the imagination exercises no mean part, are to be had; and that well debated problem obtrudes itself, whether organic life is spontaneously generated;—whether new beings can come into existence *de novo* without the aid of previous organisms or of their germs.

This vexed question I leave you to form your own opinion upon, according to the evidence that may be placed before you. Suffice it that I have indicated, however imperfectly, another phase of operations of the smallest created beings.

The diffusion of infusoria throughout the world, whereever moisture and water are found, and to a greater or less extent mostly in a latent mode of existence,—in an encysted form, and in germs, in dry soil and floating in the atmosphere, is a well recognised fact, and one immediately realised by the mind. But that such tiny creatures should contribute in no small degree to the building up of the crust of the earth, both at remote epochs and also at the present day, is a fact that at the first blush appears startling. Investigation, however, at different parts of the earth's surface and by soundings over the bottom of the ocean have demonstrated the truth of the fact referred to.

This result is brought about by forms of microscopic life which possess an external coat or shield of silicious or of calcareous matter, and which, consequently, from the weight of their armour, tend to subside to the bottom of the water in which they occur. Two groups of beings invested with cases of mineral consistence are dis-

tinguished. One furnished with a silicious coating is found chiefly in fresh water, the other provided with, in by far the great majority of species, a calcareous investment, is almost limited to sea water. The former are known as the diatomeæ or diatomaceæ; the latter as the foraminifera or polythalamia. There is beside a third group, characterised by having a mineralised framework giving support to the tender living animal matter described under the name of polycystina.

The mud of rivers and ponds is usually rich in diatoms, and the mud dredged from the bottom of the sea is even more prolific in foraminifera. As after the death of the beings their cases remain, it follows that there must be a progressive accumulation of emptied shells. What such accumulations may amount to, and what an amount of prolific microscopic life may be imperceptibly proceeding, is displayed by deposits from still living aggregations of such organisms, and still more forcibly by their debris as found fossilised in various geological formations, dating back to the remotest period, though more common in deposited rocks of the tertiary series.

The length to which this address has extended warns me of the necessity of curtailing greatly the illustrations that could be furnished of the facts just stated. I will first quote an example from Dr. Hooker of existing operations of diatoms in building up strata remarkable for their extent. "The waters" (Dr. Hooker writes), "and especially the newly-formed ice of the whole Antarctic Ocean, between the parallels of 60 and 80 degrees south, abound in diatomaceæ so numerous as to stain the sea everywhere of a pale ochreous brown, the surface having that colour as far as the eye can reach from the ship * * *

Their death and decomposition produce a submarine deposit or bank of vast dimensions, consisting mainly of their silicious shields intermixed with infusoria and mineral matter. Its position is from the 76th and 78th degree of south latitude, and it occupies an area 400 miles long by 120 wide."

As an example of an ancient deposit take the statement of Dr. Bailey, of New York, of the existence of a white layer of a porcelain clay, allied to the polishing powder known as tripoli, 500 feet in thickness, composed almost entirely of the remnants of these minute beings. This is an example of a deposit of extraordinary thickness, but many strata of similar composition reach from thirty to fifty and seventy feet.

Hurrying on to the other class of microscopic shells remarkable for rearing deposits of magnitude in the earth's crust, namely, to the foraminifera, I will just mention that the limestone formations generally, and especially the late chalk deposits, are essentially accumulated masses of foraminiferous shells.

The same activity and energy of the extremely little in building up what is colossal, is exhibited at the present day also by these same calcareous-shelled organisms. Dr. Carpenter's dredgings, particularly those in the Atlantic Ocean, have shown the bed of the ocean to be formed of a thick deposit of such shells. The mud he calls "globigerina mud," because of the great abundance in it of the particular genus globigerina, and he regards the accumulation as equivalent to the formation of a stratum of chalk extending over a large part of the Atlantic sea bed.

Professor Agassiz has of late been similarly engaged in dredging observations off the coast of North America, and finds there more or less extensive agglomerations of foraminifera. Dr. Carpenter and others have built on the discovery of those beds of calcareous mud the hypothesis of their continuity with the chalk of ancient time, and so represent us as still living in the cretaceous epoch. The author of this hypothesis has the support of several naturalists, but Sir Charles Lyell has declared against him, and consequently the notion remains a debatable matter. However, the abandonment of the hypothesis would in no way lessen the truth of the fact of the important place occupied by these smallest of beings in the building up of the earth's crust.

I did intend to sketch the operation in the same direction of other small beings, though large in comparison with those we have been considering, namely, the sponges and corals, but your patience must be exhausted, and I must at once conclude this lengthy address, by thanking you for the kind attention you have vouchsafed me and wishing for the increased success and usefulness of the association.

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ON LIMESTONE,

ITS OCCURRENCE, NATURE, AND ORIGIN.

BY THOMAS WARDLE, F.G.S.

THE rocks which constitute what is termed the earth's crust are conveniently grouped into two great classes—those formed in or by the agency of water, and those of igneous or volcanic origin. It is beyond the province of the present address to treat of those great rocks which are the result of subterranean heat, such as basalt, trap, and the various kinds of lava, or of the great mountain masses of metamorphic sedimentary rock which have been so altered by the effects of igneous power and proximity as to lose nearly all trace of their aqueous origin, such as the gneissic, quartzite, and schistose rocks. Rocks of the first-mentioned class, those of aqueous or watery origin, may also be subdivided into two classes—those which are of sedimentary origin, and those which have been formed in the deeper waters, mainly out of the reach of sedimentary matter. Sir Charles Lyell divides them into mechanical and chemical deposits. The sedimentary rocks are those which are composed of the detritus, waste, or wash, more or less worn, of previously formed rocks: they are mere sediments formed into beds of strata by moving water carrying in suspension frag-

mentary matter more or less comminuted, and which by the simple force of gravitation have settled to the bottom as soon as the stream or current became still and deep enough.

Such are the great sandstone rocks of England, well represented in the millstone grit series, and in the great triassic beds which cover such large areas in Cheshire and the Midland counties, and known more familiarly by the name of new red sandstone. The process of formation of sedimentary rocks is well described by Professor Ramsay, who writes,—"Suppose a river flowing into the sea: it carries sediment in suspension, and a layer will fall over part of the sea-bottom, the coarser and heavier particles near the shore, while the finer and lighter matter will often be carried out by the current and deposited further off. Then another layer of sediment may be deposited on the top, and another, and another, until, in the course of time, a vast accumulation of strata may be formed. In this manner deltas are formed, and wide bays and arms of the sea have been thus filled up. As they fill, the marshes spread further and further, and, by overflows of the river bearing sediment, rise higher and higher, till, as in cases like those of the Ganges and the Nile, kingdoms have been formed of mere loose detritus." (Physical Geology and Geography of Great Britain, p. 4.)

To show how great sedimentary rock masses and areas can be formed by what is carried into the sea by rivers, I will diverge for a minute to quote an interesting passage in Mr. Jukes's Manual of Geology. At page 401 he writes—"The total mineral matter carried down by the Ganges into the sea, according to Everest, is 6,368,077,440 cubic feet per annum. Lyell calculates that for the trans-

port of this quantity it would require a fleet of 2,000 Indiamen, each of 1,400 tons, to start every day throughout the year. Such a mass of matter would cover a square space fifteen miles in the side every year with mud a foot deep, or would raise the whole surface of Ireland one foot in 144 years. The Mississippi, according to the measurements of Messrs. Humphreys and Abbott, conveys every day into the Gulf of Mexico 53,424,657,534 cubic feet of sediment." These deposits, by the cementing power of oxide of iron, silica, great and long-continued pressure, accompanied sometimes by heat, have become hardened into rocks of various degrees of consistency, and in the case of the Pennine chain, now that the sea has been driven back, and the strata upheaved by subterranean force or lateral shrinkage, form the grand and rugged backbone of the northern half of England.

But it is not on this description of rock that I would further dwell, but on that other class which is represented by the vast accumulation of what is called limestone, an inquiry into which is the object of my address, with a view to consider and examine those methods by which it is said to have been formed into its present condition.

First, permit me to describe to you to what geologic epochs the various limestones belong, with passing reference also to the physical geology and geography of this most interesting substance. Limestone of one kind or other is a constant corollary to each geological formation and epoch. It is consequently found in the oldest rocks which show any signs of stratification. The most ancient rocks in which we have evidence of stratification are the Laurentian group, so called from the Canadian geological surveyors having found, northwards of the river St. Lawrence, "a

vast series of crystalline rocks of gneiss, mica-schist, quartzite, and limestone, more than 30,000 feet in thickness, which have been called Laurentian, and which are already known to occupy an area of about 200,000 square miles." (Lyell's Student's Elements, p. 475.) In these are several limestones, one of them from 700 to 1,500 feet thick.

The most ancient life which the earth possessed has been traced to this limestone. In it has been found that peculiar organism called Eozoon Canadense, which having played an important part in the earliest history of the globe, by building up whole reefs of limestone rock, is a pertinent subject to the present inquiry, and I cannot do better than read Sir Charles Lyell's description of it. At page 475 of his Student's Elements he writes, "In the most massive of these Laurentian limestones Sir W. Logan observed in 1859 what he considered to be an organic body much resembling the Silurian fossil called stromatopora rugosa. It had been obtained the year before by Mr. McCulloch, at Grand Calumet on the river Ottawa. This fossil was examined in 1864 by Dr. Dawson of Montreal, who detected in it, by the aid of the microscope, the distinct structure of a rhizopod or foraminifer. Dr. Carpenter and Professor T. Rupert Jones have since confirmed this opinion, comparing the structure to that of the well known nummulite. It appears to have grown one layer over another, and to have formed reefs of limestone as do the living coral-building polyp animals. Parts of the original skeleton, consisting of carbonate of lime, are still preserved, while certain interspaces in the calcareous fossil have been filled up with serpentine and white augite. On this oldest of known organic remains Dr. Dawson has conferred the name of Eozoon Canadense."

The next system is the Cambrian, which although containing fossils believed but a short time ago to represent the oldest life forms, or primordial types, has but little limestone. It is not of more interest to my inquiry than to note that it contains, in the Huronian series, an unfossiliferous limestone 300 feet thick.

The Silurian system, so named by the late Sir Roderick Murchison, is next in order, and it is in it that we first realize how vast a part in nature is played by lime, or to speak more strictly calcium, which is the chemical name for that elementary substance of which lime is an oxide. This Silurian system is well developed in Wales and Shropshire. It took its name from an old British tribe, the Silures—(Jukes's Manual of Geology, page 530)—who inhabited part of South Wales. The thickness of the various beds in this formation is estimated at about 6,000 feet. Its characteristic fossils are trilobites, which are found in great number in some of the beds of the Dudley, Wenlock, and Ludlow groups. I am indebted to my friend Mr. Hollier, of Dudley, who is an authority of high repute on Silurian fossils, for some beautiful specimens of trilobites, kindly sent for this meeting. On one slab may be counted no less than 28 portions of trilobites, besides many other organisms crowded together in wild profusion and in the stillness of death. He has also sent the series of Silurian limestones that lie on the table: they show the variations of the rock and its accompanying shale. There are about 500 species of fossil shells and organisms in the Ludlow group, in which actinozoa, brachiopoda, echinodermata and crustacea abound, as well as the remains of fishes. It is in this formation that the oldest known fishes have been found in shale below the Aymestry limestone. Thus from this period of

geological chronology we become acquainted with the existence of fishes. From the specimens on the table it will be seen that Silurian limestones are of a dark grey colour, more or less argillaceous or clayey, and interstratified with grey shales. The rock is often subcrsytalline, and contains in veins fine well-formed crystals of carbonate of lime.

In ascending in the order of time from the Silurian epoch, we come to that of the Devonian, or Old Red Sandstone. The study of this system immortalised the name of the lamented Hugh Miller. This period is doubly interesting as bringing to light the existence of the earliest known insects. Four species of the order neuroptera have been found. One species of the genus ephemera, of which the ephemera vulgator or green and grey drake flies of our rivers in June are examples, so useful in trout fishing, and so much prized by anglers, among whom is my esteemed friend Mr. Ward, who does not wholly confine his piscatorial studies to palæontological times—I say one species found in Devonian rocks measured five inches in expanse of wing. I do not know how this fact agrees with the development theory of Mr. Darwin, but I think the appearance in Dovedale of a green or grey drake fly measuring five inches across the wings, some fine afternoon in June, would astonish not a little both trout and Piscator. Dr. Dawson remarks that in one type there is the stridulating or musical apparatus like that of the cricket, and that in this structure we are introduced to "the sounds of the Devonian woods bringing before our imagination the trill and hum of insect life that enlivened the solitude of these strange old forests." (Lyell's Student's Elements, p. 440.) The limestones of the Devonian period are considerably developed in Devonshire, at Plymouth, Devonport, and Ilfra-

combe, along with the old red sandstones. There are about forty distinctive species of fossils which characterize this limestone, of which may be mentioned stringocephalus, megalodon, bronteus, calceola, cyathophyllum. There are fifty-one species of corals enumerated by Mr. Etheridge, none of which are known to have survived Devonian times. A specimen of coral of this age lies on the table. This profusion of corals may well be a strong argument of those who hold that limestones mainly owe their origin to the agency of coral reef builders.

I now come to the Carboniferous system, and to the limestone to be found in it. At the base of the coal measures in Mid-England, and separated from them only by millstone grit and Yoredale rocks, occurs the Carboniferous or Mountain Limestone. Its thickness is greatest in North Staffordshire, and is more than 4,000 feet. Its base has not yet been seen, as the formation happens to make the centre of an anticlinal fold or upheaval, and it has not been broken through. It soon dips beneath the shales and grits on each side of the fold. This limestone occurs in regularly stratified beds, some of them many feet in thickness. It is very hard and compact, generally sub-crystalline, and of a lighter grey colour than the Silurian limestone. In some places it is almost wholly composed of fossils, chiefly crinoids, brachiopoda, and conchifera. The crinoidal portions, when polished, furnish the fossiliferous marble so much used for mantle-pieces, columns, and other ornamentation. The upper beds of this limestone are characterized by being more or less cherty or siliceous. A specimen is on the table.

At Ashford, near Bakewell, much of the limestone is black, and forms the black marble used for vases

and slabs, in which the most beautiful inlaying is done and which adorns the spar and marble shops of Buxton. Mr. Woodruffe, of that town, is an artist of high skill in designing and inlaying, and his show-room is well worth visiting when the club meets there in June for its two days' excursion. We may well feel proud that we have such a fine representation of the mountain limestone formation, in the charming scenery through which the rivers Hamps, Dove, and Manyfold flow, with their cliffs and tors, with their interesting caverns and subterranean river courses, all of which give great interest to the northern part of our county, and are within easy reach of this smoky and toiling district. And proud also may we justly feel that the labours of a quiet and humble observer of this limestone, and one who was well known to most of us, have borne such interesting fruit. The late Samuel Carrington, of Wetton, in the course of a patient working extending over a series of years, brought to light no fewer than 676 species of limestone fossils, exclusive of varieties and many unnamed specimens. A list of these fossils was printed for the Leek meeting of the club in 1870. It is intended by some of the members of this club, assisted by a few other friends, to perpetuate his memory by the erection, in the summer, of a suitable monumental tomb over his remains in Wetton Churchyard. About £10 more only is required to complete the necessary amount, and I, as treasurer, shall be glad to receive additional subscriptions to that amount. May I be permitted to say for the encouragement of our young members, that Mr. Carrington's example and success may well exert very stimulating influence on those who can, like him, devote their Saturday afternoons and holidays (for he was a schoolmaster, and enjoyed his Saturdays, which always found him abroad in the best senses of the word,) to the study of the fossils

which abound in the limestone of North Staffordshire. As a further stimulus, I may mention that I know of no department of Staffordshire fossils which would so well repay the collector as that of the corals. But little has been done to collect and classify then, and what we don't know of them would fill a large book.

The conchiferous shells of the province lamellibranchiata have as yet met with but little attention. They abound in our limestone district, and will amply repay any student who takes up this branch as a speciality. The same may also be said of the gasteropoda, polyzoa, and actinozoa. The brachiopodous shells have been well worked and arranged: the species amount to about 120.

Round the base of the Caldon Low mass of limestone, and resting against its sides, is a very curious deposit of arenaceous marl or clayey sand. It is well worth visiting. It is in some parts largely mixed with decomposed siliceous pebbles. Except in colour it resembles the Bunter sands and pebble beds. It is mainly beautifully white, with streaks of yellowish aluminous clay, but here and there it is red. It is said to make fire-bricks quite equal to Stourbridge clay, and it has lately begun to be excavated for that purpose. It appears to me to be of Triassic age, and seems to have been acted upon by its proximity to the limestone. There are other deposits of it in this limestone district.

The Permian system, which succeeded the carboniferous, is that in which was formed magnesian limestone or dolomite. This singular product is largely developed in the North of England, especially in Durham and Yorkshire. York Minster and the Houses of Parliament are built of

it. The Permian system is the youngest member of the primary or palæozoic group, and its fossils are closely akin to those of the carboniferous times. "It forms," says Professor Ramsay, "a narrow and marked strip on the east of the coal measures from Northumberland to Nottinghamshire, where it chiefly consists of a long, low, flat-topped terrace of magnesian limestone, interstratified with two or three thin beds of red marl, sometimes containing gypsum. The scarped edge of this limestone, which is sparsely fossiliferous, faces west, and overlooks the lower undulations of the coal measure area. Before the end of this palæozoic epoch, the Permian beds were deposited in great inland salt lakes analogous to the Caspian Sea and other salt lakes in Central Asia at the present day. That area gives the best modern idea of the state of much of the world during Permian times." (Physical Geography and Geology, p. 81.) The limestone of this period in the North consists of two beds, one of thin-bedded grey limestone, 80 feet thick, and the other of magnesian limestone, 500 feet thick. The characteristic fossils consist of about 24 species, according to Professor King, and are comprised in seven families, of which may be mentioned polyzoa, brachiopoda, conchifera, and gasteropoda. The prevailing colour of this limestone is yellowish.

I have now completed my description of the physical geology of the primary or palæozoic limestones, and come to the mesozoic or secondary, the first of which occurs on the Continent in the Triassic beds, but not here, and is known by the name of muschelkalk, so named from the shells it contains. Its thickness is nearly 600 feet.

The next formation is one in which limestone plays an important part. It is called the Jurassic or Oolitic

system—Jurassic, from the Jura mountains, where its limestones are grandly developed, and Oolitic from the peculiarity of some of its limestones being formed of granulated particles of an egg-shaped form, or like the roe of fishes. Bath and Caen stones represent this structure. The thickness and number of beds of limestone in this formation are very considerable. Fossils abound in them, from the great saurian reptiles of Lyme Regis and Barrow, to the beautiful forms of the lily encrinite. Specimens of liassic limestones and fossils lie on the table. The lias limestones are dark-coloured and earthy: they form, when burnt, what is called water lime, which has the property, when made into mortar, of hardening under water. Bath and Caen stone occur in this formation, and are extensively used in carving and internal architectural decoration. They are so soft as to be easily sawn, but harden considerably on exposure.

From the Jurassic we ascend into the Cretaceous or Chalk formation. This is the uppermost or newest member of the Secondary system. The appearance of chalk is too well known to need description. It is a limestone like the others, save in appearance. It is divided into chalk without flints, 600 feet in thickness; chalk with flints, upwards of 1,000 feet thick; and Maestricht or pisolitic chalk and Faroe beds, 100 feet thick, in which are the extensive and celebrated caverns at Maestricht in Holland. Chalk is most extensively developed in England, and covers more ground than all the other limestones put together. From Flamborough Head, in Yorkshire, it extends to the south-east coast, and as far westward as Sidmouth, being sometimes covered by Tertiary rocks. The fossils are very numerous, seventy species being characteristic of it. When a piece of chalk is carefully

rubbed to powder in water, and the lighter particles poured off, a great number of beautiful forms are revealed by the microscope. They consist of foraminiferæ called globigerina, sponge spicules, &c. There is an interesting slide of them under the microscopes.

The close of the chalk period marks the end of the geological division of the secondary epoch and the advent of Tertiary, the lowest member of which is the Eocene group. It was in this period that another grand limestone deposition took place, which extended from the Alps to the Himalayas. It is often found several thousands of feet in thickness, and consists of myriads of a characteristic foraminiferæ called nummulites, from their resemblance to a coin. The nummulite resembles in form and size a worn sixpence, although much more convex. Under the microscope it is revealed as a many-chambered shell of complex organization. This extent of nummulitic limestone is almost amazing: a band of it, often 1,800 miles in breath, extends from the Alps to China. The Pyramids are built of it. It forms some of the highest mountain ranges of the Alps and Pyrenees. It is found on the Alps at a height of 10,000 feet, and forms the summits of the Dent du Midi and Diableretz, whilst in the Himalayan mountains it has been recognized by Dr. Thompson 16,500 feet above the sea. Nor is the profusion of its traces of life less amazing. It may be safely said that much of it is almost entirely made of nummulites. There is a good though small specimen on the table, which shows the nummulitic form very well, and there is also a slide under the microscope showing the structure.

Whilst this immense area of comparatively recent limestone was being formed, what was the condition of those

extensive portions of the continent of Europe, Asia, and Africa at that time? The nummulites were marine and lived and died in the sea; consequently the sea was moving over a flat expanse of the earth's surface which is now marked by the great mountain ranges of the Alps, Pyrenees, Carpathians, and Himalayas. Sir C. Lyell says these mountains could have had no existence till after the middle eocene period, the antiquity of which is, as I have just stated, but trifling when compared to that of the Silurian or carboniferous age. "How comparatively modern then," observes Sir C. Lyell, "is the date to which some of the greatest revolutions in the physical geography of Europe, Asia, and North Africa must be referred!"

It is said that ordinary limestone intensely heated in closed vessels assumes the crystalline form. This must of course be without access of air, and under circumstances which prevent the escape of carbonic acid. The saccharoid, white crystalline, or statuary marble of Italy is said to be the result of this action.

Between the middle eocene period and the present there have been formed, as far as we at present know, no limestones of like magnitude. They may be briefly enumerated as follows:—The Bembridge series of limestones, some of which were formed in fresh and brackish water, because they contain fresh water fossils. They are of upper eocene date. The Sicilian limestones are of pliocene age: they cover half the island of Sicily. These bring us to limestones of the recent or human period, and as I before stated each great period had its limestones, the same may be said of the present, which is as much a geologic period as any of its predecessors. Wherever

there is sea there may be found in some parts or other of it a growing quantity of limestone. In our times it is represented by the great coral reefs now forming in the bed of the deep sea, and in the accumulation of beds composed of marine shells. This accumulation of limestone will compare with that of any of the previous geologic epochs; nay, it will most probably surpass them. It seems as though the older the earth grows the more favourable is it for the forming of limestone. In the Indian and Pacific Oceans, vast coral reefs are being slowly but surely raised. They have been traced for 6,000 miles in the latter, and in depth to more than 2,000 feet. Mr. Jukes estimates that many thousands of years must have been required for these tiny coral builders to raise the barrier reef of Australia.

The recent dredging researches in the Atlantic have proved the existence of a soft bed of mud or ooze, which when dried resembles chalk. It extends over the whole floor of the Atlantic, except in the neighbourhood of cold currents. Dr. Carpenter states that at a depth of three miles he brought up in the dredge 1½ cwt. of this ooze. Ninety-seven per cent. of it consists of microscopic rhizopods, or foraminiferous shells, which are the same globigerinæ I spoke of as constituting the bulk of chalk, and those who favour the development theory have seized on this fact as proving a continuity of specific forms of life, at least from the chalk period to this. This, however, meets with a serious check interposed by Sir C. Lyell, who asks them to produce, in a living form, the now extinct shells which characterized the chalk period. You will find under one of the microscopes the globigerinæ brought up by the dredge in the Atlantic dredging expedition from a depth of two miles. You will have a good

opportunity of comparing them side by side with their congeners of cretaceous times.

I have now shown the distribution of limestone throughout the successive geological epochs. My brief description would, however, be incomplete if I omitted to mention the views of Mr. Hull, M.A., F.R.S., who in a paper in the Geological Magazine for 1869, p. 364, has shown very strong evidence of a ternary classification of rocks. He points out an unmistakable tendency in each geological formation or group of strata to assume a threefold arrangement, having sedimentary matter for the upper and lower members, with a central calcareous member interposed, and that this arrangement is repeated in all the series from the Laurentian to the tertiary times. From this Mr. Hull argues that geological history has repeated itself in cycles, every epoch having, as at present, depositions of sedimentary matter over wide littoral areas, with the accretion of limestone and calcareous matter in the deep sea, out of the reach of sediments which represent the more littoral conditions, whilst the calcareous represents the pelagic or deep sea conditions of each cycle of time. He thus tabulates the supposed arrangement :—

A Natural Group.—Lower stage, representing prevalence of land with movement, producing chiefly sedimentary strata. Middle stage, representing prevalence of sea with quiescence, producing chiefly calcareous strata. Upper stage, representing prevalence of land with movement, producing chiefly sedimentary strata.

This grouping is well represented by the Triassic series with its new red sandstone and Bunter beds for the lower stage, muschelkalk limestone for the middle stage, and red marls and Keuper sandstones for the upper stage.

I will now briefly turn to the nature and composition of limestones. They are all mainly composed of calcium, oxygen, and carbon, or what is commonly called carbonate of lime, the formula of which is $CaCO_3$ or $CaOCO_2$, that is, one molecule of oxide of calcium, which is lime, united with a molecule of oxide of carbon or carbonic acid; or, an atom of calcium united chemically to an atom of carbon with three atoms of oxygen; or, to be more precise in stating their respective affinities, one atom of calcium united with one atom of oxygen forms oxide of calcium or lime: this combination or molecule combines with another, consisting of one atom of carbon united with two atoms of oxygen or carbonic acid, and forms limestone, and it is the same whether it occurs as calc-spar, chalk, oolite, coral reef, Atlantic ooze, the shells of molluscs, or the egg-shells of birds.

In the case of magnesian limestone it is different: it then contains upwards of 20 per cent. of carbonate of magnesia. The quantity of magnesia is however variable. Magnesian limestone is said to be the result of the gradual metamorphosis of ordinary limestone, carbonate of magnesia replacing carbonate of lime. To my own mind this mode of accounting for the difference is doubtful, as sea water usually contains more carbonate of magnesia in solution than carbonate of lime. But limestones are all more or less impure. My friend Mr. Woodcroft, who has very kindly and at considerable trouble made a careful examination of the mountain limestone of Caldon Low, gives the following as the result of his analysis:—Carbonate of lime, alumina, silica, carbonaceous matter, and a trace of iron. Out of 30lbs. of limestone dissolved in hydrochloric acid, the residue well washed with distilled water, he found 680 grains of mud, consisting of alumina

for the most part, and carbonaceous matter 1,260 grains, or nearly 3 oz. of silica, which when we put it under the microscope we were delighted to find consisted entirely of microscopic crystals of six-sided prisms, terminated by six-sided pyramids, the usual form of rock crystal. It may be accepted as a fact that in the mountain limestone these beautiful crystals are prevalent. Mr. Woodcroft has dissolved many pieces, and has always found them. In the Buxton limestone they occur in larger crystals, and a little worn or corroded, but in that of this locality (except in the hydraulic mountain limestone of Waterhouses, near Leek, in which the silica occurs in an amorphous form,) they are always perfect in form, translucent, and very interesting objects, averaging in measurement about the 400th of an inch in length by the 1,000th of an inch in breadth. The smallest are less than 1,000th of an inch long. The crystals obtained from both the Buxton and Caldon limestones are under the microscopes, and this bottle contains the 3oz. of crystals obtained from the 30lbs. of limestone. They are at the disposal of any ladies or gentlemen who may be desirous of having some for microscopic objects. They are as interesting and as beautiful polariscope objects as any I know of, and those who have to their microscopes the accessories for polarized light will derive much pleasure in their examination. The encrinital slabs which seem wholly composed of fossils also contain these crystals. They do not appear to be present in the liassic, oolitic, or Silurian limestones.

I shall conclude my paper by a short enquiry into the origin of Limestones. How were they formed? There can be no doubt that the sea owes the limestone it contains in solution to its solvent action on rocks containing lime, and to the carbonate of lime brought down into it

by rivers holding it also chiefly in solution. The way in which limestone gets into solution is as follows:—Rain water is of course not charged with mineral matter, but it contains carbonic acid, which it carried with it whilst being evaporated from the sea or other waters, as well as an additional quantity which it absorbs during its aerial sojourn. In this state it has considerable dissolving power on carbonate of lime. Limestones are dissolved in large quantites by it, as may be seen by the smoothed surface of the rocks when exposed to the weather: they may be seen to be worn into fantastic shapes, and with corals, stems of crinoids, and shells standing out in relief because of their harder and more compact structure. In this way the extensive caverns in the limestone formations have been produced. The sea water having been shown to be the great reservoir of limestone in solution, the question arises, How does it become re-formed into rocks? Professor Ramsay says that all the carboniferous limestone owes it origin to marine life of various kinds, which separated or secreted lime from the water. He states at p. 77 of his Physical Geology that the carboniferous limestone is entirely formed of sea shells, encrinites, corals, and other organic remains, and at p. 11, "In many a formation, for instance, in some of the beds of the carboniferous limestone, the eye tells us that they are formed perhaps entirely of rings of encrinites or stone-lilies, or of shells and corals of various kinds, or of all these mixed together; and in many other cases where the limestone is homogeneous the microscope reveals that it is made up of exceedingly small particles of broken organic remains. Even when these fragments are indistinguishable, reason tells us that such marine limestone deposits must have been built up of the debris of life, for there is no reason to believe that vast formations of limestone, extending

over hundreds of square miles, are now or ever have been precipitated in the open ocean from mere chemical solutions. It sometimes happens, indeed, that gradual accumulations of such beds of limestone have attained two or three thousand feet of vertical thickness. By little and little limestone is abstracted from sea water to form parts of animals, which dying in deep, clear water frequently produce by their skeletons and shells immense masses of strata of nearly pure limestone, which is consolidated into rock almost as fast as it is formed." And in a lecture in a Dudley Silurian pit, which I had the honour of hearing, he stated the Silurian limestone to be also the result of marine life agencies. His opinion is therefore as clear as it is clearly stated, and it is shared by other leaders in geological science. There must therefore be very weighty reasons for such a conclusion, and it is scarcely the province of the amateur geologist to question them.

My own observations, however, imperfect and immature as they necessarily are, lead me to inquire for additional constructive agency for our mountain limestone. Whilst far from disputing Professor Ramsay's conclusion, I am at a loss to account for the unfossiliferous parts which limestone undoubtedly contains. Much of it is crystalline, as is the case with the silica it contains. May not chemical forces similar to those which crystallized the silica have also separated some of the limestone? Or is the crystallization of both a result which took place after the consolidation of the rock? And if so, why do we find the silica so perfectly crystallized in a mass of amorphous or subcrystalline limestone, if each molecule of the limestone has been drawn together by life agency solely? We all remember the experiment of forcing carbonic acid gas,

as it is expelled from our lungs, through lime water. The lime unites with the carbonic acid and separates in a milky precipitate from the water; but if a continued supply of this gas is kept up the carbonic acid becomes a solvent and all the lime goes into solution again, not as a bicarbonate, as might be and is supposed, but simply as carbonate of lime ($CaOCO_2$) dissolved mechanically by an excess of carbonic acid. Is it not possible for there to be conditions in the sea, as yet unnkown to us, under which the excess of carbonic acid may be withdrawn? Then the limestone would be deposited. This process I suggest may be the corollary to the organic one, and both animal and chemical agency may be simultaneous or alternating. We should then get the result we now see, namely, limestones composed of partly mineral and partly structural matter, and should get the same mineral result as we see in stalactitic and crystalline accretions, and partly in the same way with the addition of fossil forms. But the weighty and authoritative argument of Professor Bischoff goes entirely the other way. He says it is impossible for carbonate of lime to be precipitated in the sea, because there is a slight excess of carbonic acid always there, which is more than able to dissolve all the lime that is being poured into it by rivers and tidal action washing against limestone coasts. He also says that the lime thus coming into the sea is in quanity just what is extracted from it by shell fish, &c., and so a kind of balance is kept up. He states that sufficient lime is annually carried into the sea by the river Rhine to give shells to 332,539 millions of oysters. He found a little more than 1½ per cent. of carbonate of lime in the sea water between England and Belgium, and 1½ per cent. of carbonate of magnesia. He gives the quantity of carbonic acid present in sea water to be five times

greater than is required to hold the carbonate of lime in solution, and says that even if a temporary precipitation took place it would almost immediately be redissolved by this free carbonic acid. He also says it is only through organic or life agency that carbonate of lime can be secreted from sea water.

To this ought to be added the testimony of Mr. Hull from his paper previously quoted. He is a believer in the organic origin of limestone, as will be seen from the following interesting table, which he terms "a synopsis of the chief limestone builders of successive geologic periods in ascending order":—

LAURENTIAN.	Foraminifera (?). *Eozoon.*
SILURIAN and DEVONIAN.	Corals, chiefly of the orders *Zoantharia tabulata*, and *Z. rugosa* of MM. Milne-Edwards and Haime), Crinoids, Brachiopods, and Entomostraca.
CARBONIFEROUS	Corals, *(Zoantharia tabulata, Z. rugosa, Z. tabulosa)*, Crinoids, Bryozoa, Brachiopods, and Entomostraca.
PERMIAN	Corals (not abundant; *Zoantharia tabulata, Z. rugosa*,) Bryozoa, Conchifera, Entomostraca.
TRIASSIC	Bryozoa, Echinoderms, Conchifera.
JURASSIC	Corals *(Zoantharia aporosa)*, Bryozoa, Echinoderms, Molluscs largely.
CRETACEOUS	Amorphozoa, Foraminifera, Corals *(Zoantharia aporosa, Z. tabulata, Z. rugosa)*, Echinoidæ, Bryozoa, Entomostraca, Brachiopods, (Terebratulæ).
TERTIARY	Foraminifera, (Nummulites), Corals *(Zoantharia aporosa, Z. perforata, Z. tubulata)*, Echinoderms, *(Echinoidæ, Asteroidæ)*, and Ophiuridæ.

Although I have been searching for facts without prejudice, the wish was almost father to the thought that I

might find the amorphous and subcrystalline portions of the mountain limestone without evidences of life, but I am bound to admit that on having sections of it made I was amazed at the amount of foraminiferous life it discloses. These sections, which I have had prepared by Messrs. R. & J. Beck, of London, and by Mr. Dancer, of Manchester, are of great interest and go far to confirm all that Professor Ramsay, Dr. Carpenter, and Professor Bischoff have said ; but there are parts in the mountain limestone sections devoid of life forms, whilst some of those from liassic and other limestones appear to be entirely unfossiliferous. You will see in the liassic one under the miscroscope that it is but very sparsely populated with life remains, but has its bulk made up of limestone of a less pure kind than the carboniferous. Some of the beds in both formations are very earthy, some very carbonaceous, some very sandy: and I hope I may not be considered presumptuous if am tempted to ask if there is no other than life agency able to separate limestone from the sea water.

We know that the great travertine or tufaceous deposits are the results of the voluntary separation of carbonate of lime from water which held it in solution. We know that in our kettles and steam boilers thick deposits of the same substance are gradually formed, but we also know that such separation is the result of the expulsion by heat or otherwise of the excess of carbonic acid which held it in solution. There are numerous instances of calcareous deposits in lakes, rivers, and seas. For example, in the river Lathkill, in Derbyshire: its bed is covered with deposited carbonate of lime, and here is a specimen of moss entirely encrusted and hidden by it, from the same locality. There is a deposit in the

lake of Constance containing 30 per cent. of carbonate of lime.

Bischoff himself in another part of his great work on Chemical Geology writes, "In the sea, and especially on the coasts, the condition for the deposition of carbonate of lime exists, and there the agitation of lime in the water exists to the greatest extent, that is, in allowing carbonic acid to get more intimately mixed with sea water, and so to precipitate chemically the carbonate of lime." This statement appears to me to be at variance with what I have quoted from the same author on the previous page.

The following extracts from Mr. Sterry Hunt's work on the chemical and mineralogical relations of metamorphic rocks, with which I was unacquainted when I wrote this address, and which have been since pointed out to me by Mr. J. Plant, of Manchester, will help to show there are weighty reasons for doubting the theory of the organic origin of limestone.

He writes, "It cannot be doubted that in the earlier periods of the world's history chemical forces of certain kinds were much more active than at the present time. Thus, the decomposition of earthy and alkaline silicates, under the combined influence of water and carbonic acid, would be greater when this acid gas was more abundant in the atmosphere and the temperature probably higher. The large amounts of alkaline and earthy carbonates then carried to the sea from the decomposition of these silicates would furnish a greater amount of calcareous matter to the sediments."

The sources of the carbonates of lime and magnesia in

sedimentary strata are twofold—1st, the decomposition of silicates containing these bases—such as lime, feldspars, and pyrox; and 2ndly, the action of the alkaline carbonate, formed by the decomposition of feldspars, upon the chlorides of calcium and magnesium originally present in sea water, which have thus in the course of ages been in great part replaced by chloride of sodium. The clay or aluminous silicate which has been deprived of its alkali is thus a measure of the carbonic acid removed from the air, of the carbonates of lime and magnesia precipitated, and of the amount of chloride of sodium added to the waters of the primeval ocean.

I accept in its widest sense the view of Hutton and Boue—"that all crystalline stratified rocks have been produced by the alteration of mechanical and chemical sediments."

On the occurrence and probable origin of intercalated limestone and dolomite Mr. Hunt writes at p. 464, "The magnesian rocks among the unaltered sediments of the Hudson River group afford an interesting study. The dolomites of Pointe Levis, are interstratified with the pure limestones, sandstones, and graptolitic shales of the Quebec division of the Hudson River group. Both limestones and dolomites are very irregular and interrupted in their distribution, the beds sometimes attaining a considerable volume, while at other times they thin out, or appear to be replaced with sandstones. The limestones frequently form masses of many feet in thickness, which are without any visible marks of stratification, and destitute of organic remains. These masses are compact, conchoidal in fracture, sub-translucent, and exhibit a banded agatized structure, which leads to the conclusion they are chemical deposits

from water; in fact, veritable travertines. Interstratified with these travertines, however, there are beds of fine granular opaque limestones, weathering bluish-grey, and holding in abundance remains of orthoceratites, trilobites, and other fossils, which are replaced by a yellow-weathering dolomite."

"The facts which we have indicated clearly show that the dolomites just described have been precipitated from water, under conditions which brought more or less sand and clay, and sometimes fragments of the adjacent rocks, into the basins where this process was going on, during the intervals of which the travertines and fossiliferous limestones were deposited, to the exclusion of magnesia. Similar conditions are met with in some limestones of the Niagara division, in the eastern basin, where purely calcareous corals, of many species, are embedded in a paste of granular magnesian carbonate of lime, which would seem to have been precipitated in the medium where the zoophytes grew. A somewhat different process is presented in the replacement, by dolomite, of fossils in the limestone at Pointe Levis, as well as many localities in the Chazy limestone, where various shells are replaced, and sometimes entirely filled, with a crystalline ferriferous dolomite, the surrounding limestone being destitute of magnesia and iron. It is known that those mineral waters which hold large quantities of carbonate of lime and magnesia in solution deposit only the lime on exposure to the air, and retain all the magnesia in solution: hence travertines and tufas, both ancient and modern, contain little or no magnesia. The carbonate of this base is soluble to a considerable extent, in solutions both of magnesian and alkaline salts, but is deposited when those solutions are boiled, or evaporated at low temperatures. Thus the

alkaline waters of Carlsbad in Bohemia, which contain, according to the analysis of Berzelius, seventeen parts of carbonate of lime for ten of carbonate of magnesia, deposit great masses of travertine, which is purely calcareous, but if suffered to evaporate in open basins would afterwards yield dolomite or magnesite."

Without venturing to dispute the learned conclusions of the authorities I have named, as to the organic origin of the mountain limestone, I think I have stated grounds sufficiently weighty for me to plead for a further inquiry, with a view to ascertain whether there may not have been the twofold agency at work (chemical as well as organic,) to produce such stupendous results as those I have so imperfectly attempted to describe.

ON THE INTERMENTS OF PRIMITIVE MAN.

BY J. BARNARD DAVIS, M.D., F.R.S., F.A.S.

In the summer of 1871, a cairn was opened near to Caldon Low, at which several members of the club were present by the polite invitation of Mr. T. Redfern, of Leek. Many human bones were met with during the excavation, and pieces of charcoal, and also a few rude flint chippings. When the bones were exhibited at the next ordinary meeting of the club by Mr. Garner, the following paper was read. Mr. Garner described the peculiarites of the bones, pointed out to which sex they belonged, and the forms of the fragmentary skulls.

This cairn and its contents undoubtedly belong to what has been designated the Round Barrow period, or the Bronze age, although no remains of bronze were actually met with. The finding of such implements must of course, in many cases, depend upon circumstances of an entirely accidental nature.

Numerous and very searching investigations have been made during the present century into barrows, cairns, lows, and other depositories in which the remains of man and his works have been met with. The early inhabitants of many countries—the Ancient Britons, for example—were accustomed to dispose of the dead reverently, interring them in these structures, and showing their participation

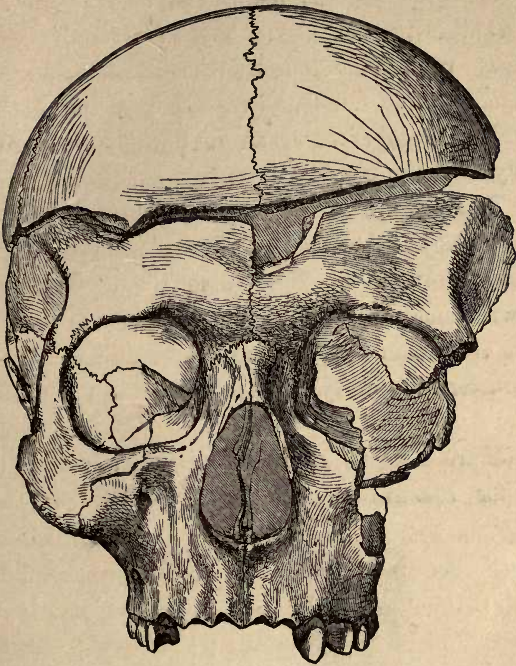
in the tenderer feelings of the human mind by heaping up such memorials of the deceased, as records of their qualities and virtues. Such investigations as we have alluded to have been extended over many of the countries of Europe, and even further, besides the British Islands. These inquiries have been undertaken with much care by some few observers, and pursued in an enlightened spirit of investigation, with the mind imbued with all the necessary preliminary knowledge. Hence results of the greatest importance and interest have ensued, and the investigations have now been sufficiently numerous, and have been so well considered, that conclusions of the greatest value may be regarded to have become well established. It may be well to glance at the chief features of these investigations of barrow diggers, and then to dwell upon two or three of the leading principles which have led to valuable results.

Two different modes of interment prevailed in ancient times among many races of people—that of burning the body, or cremation, then often gathering the ashes in an urn; and that of simple burial in various forms. Both these modes of disposing of the dead were practised by our remote ancestors, as well as by other peoples of antiquity, as the Ancient Greeks, for Homer describes both, the former, or cremation, in the cases of Patroclus and Hector, and others. It has often been a question whether the one mode or the other was first practised, but there does not appear to be any reason to doubt that both modes of interment were contemporaneously used from the earliest times.

Amongst all primitive peoples it was a practice to inter with the dead different objects. These have been very

varied. Yet the practice itself leads to a safe inference of the utmost interest in the history of the human race. It satisfactorily proves that man has always aspired to a continuance of his existence in a future life. This is perhaps the surest and most essential evidence of the community of human nature, that mankind are animated and actuated by the same hopes. The Ancient Britons, at the earliest and rudest period, must have had ideas of a life after the tomb, or they could not have buried in the barrows vessels containing food, articles of dress, ornaments, and objects employed in the chase and in war. Even when they went beyond these simple provisions for the future life, and sacrificed the chief's favourite horse, his slaves, and his wives, to be buried with him, it was in obedience to the same dictates of a hope in the future. That our ancient predecessors here upon British soil practised such dreadful customs there is no reasonable doubt. In some British barrows, where interment has been by incremation, it has been repeatedly observed that besides the ashes of the principal interment in the centre, there have been found heaps of ashes around this principal body, which there are adequate reasons for regarding to be those of slaves or wives sacrificed at the funeral rites.

About ten years ago two large barrows were opened, one in Gloucestershire, by the Rev. Canon Lysons, and the other by the late Dr. Thurnam, in Wiltshire, which gave singular and, it may be said, appalling testimony to the practices which have been mentioned. In these barrows human skulls were found. In the first-mentioned there were no less than four of them which had been cleft by frightful blows, no doubt during the lives of their possessors, in order to do honour to the obsequies of a chief. They belonged to young men in the vigour of age.



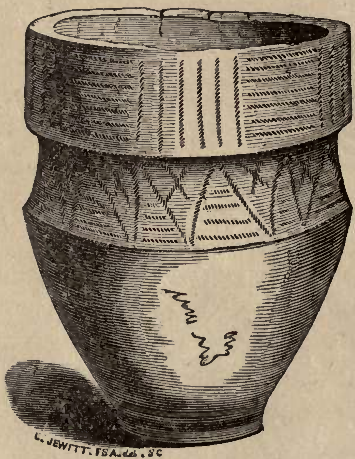
No. 1.—CLEFT SKULL OF A SLAVE, RECOVERED FROM THE RODMARTON LONG BARROW, GLOUCESTERSHIRE.

The figure (No. 1) is an exact representation of one of them, from the Rodmarton long barrow. It exhibits the effects of terrific blows given at the funeral. In other barrows cleft skulls have been met with, beside the principal interment, of women and of children, who in like manner have been immolated in honour of the dead.

Vessels of various forms have been met with in the excavation of barrows. They are made entirely by the hand, for the potter's wheel, although so very ancient a machine, was entirely unknown to the primitive inhabitants of this

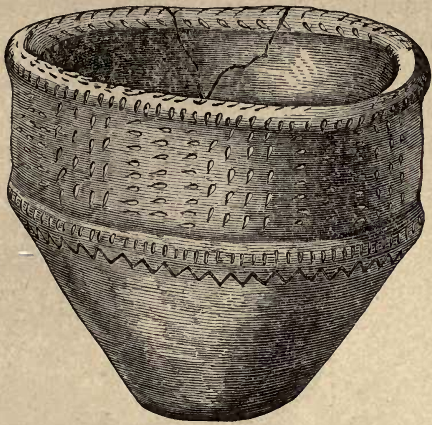
island. It may also be mentioned as a fact of much interest at the present day, that there is every reason to infer they were moulded by the delicate fingers of the women of the tribes. These vessels have not been exposed to any high temperature, as in burning modern pottery, but only slightly burnt, commonly by placing fire within them. But they differ greatly in another particular from modern pottery: they exhibit much variety in the patterns impressed upon them. The women had evidently followed their own fancies in the ornamentation of these vases, and they are free from that sameness and uniformity which are the characteristics of Staffordshire wares.

The different kinds of vases, of which we shall present figures for illustration, discovered in barrows have been



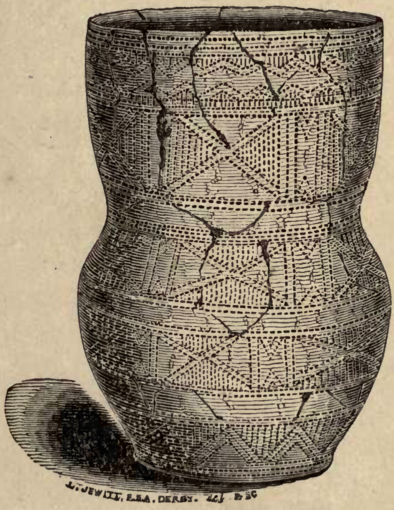
No. 2.—LARGE CINERARY URN, FROM BALLIDON MOOR BARROW, DERBYSHIRE: HEIGHT, 11 INCHES.

divided by antiquaries into cinerary urns for the reception of the ashes of the dead; food vessels, which the remains



No. 3.—FOOD VASE, FROM ACKLAM BARROW, E. R., YORKSHIRE: HEIGHT, 5·5 INCHES.

met with in them clearly prove to have contained articles of food when buried with the dead; and drinking cups,



No. 4.—DRINKING CUP, FROM GREEN LOW BARROW, DERBYSHIRE: HEIGHT, 7·4 INCHES.

which likewise, by the appearances they present in their interiors, plainly show that at the time of interment they held liquids designed to satisfy the thirst of the deceased. Another form of vases, for all these different vessels are distinguished by separate and readily discriminated forms, named incense cups, is not so certainly known to have

No. 5.—SMALL INCENSE CUP, FROM WETTON HILL BARROW, DERBYSHIRE. HAS FOUR LOOPED EARS FOR SUSPENSION: HEIGHT, 4½ INCHES.

been appropriated to some special purpose. This name was given by a distinguished antiquary, Sir Richard Colt Hoare, who at the beginning of this century directed such great attention to the opening of the barrows of Wiltshire. And my late coadjutor, the last, most exact, and most learned barrow digger, after considering the various suggestions thrown out to explain their probable uses, is inclined to think that they really contained incense and perfumes that were thrown into the funeral pyre.

It is now a number of years ago, perceiving the vast interest that attached to the human remains discovered in Ancient British barrows, especially the skulls of those who had been interred in them, which at one period contained the great centres of their nervous systems, from which emanated all that we understand by the lives and

NO. 6.—SECTION OF PARSLEY HAY BARROW.

characters of their owners, I conceived the idea of preserving accurate representations of these skulls, and placing on record all their peculiarities, as well as a correct description of all the relics disinterred with them, which seemed to me distinctly requisite, because the skulls themselves are disinterred from the barrows in an exceedingly fragile and perishable condition. It was this idea that ultimately led to the preparation and issue of the "Crania Britannica."

In order to indicate the singular, sometimes even bizarre, positions in which the remains are found in barrows, my description of the Parsley Hay Low may be quoted from the work just mentioned. It is there related that the Parsley Hay Low is a tumulus of stone situated in the parish of Hartington, in the county of Derby, which was opened on the 6th of March, 1848, by the late Mr. Bateman. The section of the barrow (No. 6.) will convey better than any words the position of the skeleton. "It had been deposited in a narrow oval fissure of the rock, about three feet deep, too narrow to admit of reclination in the usual primitive flexed position. The body had consequently been placed in a sitting posture. In this respect it is perhaps unique amongst the Derbyshire barrows hitherto examined, although such mode of depositing the body has been observed by Sir R. C. Hoare in a Wiltshire barrow; and Dr. F. C. Lukis, in the cromlech du Tus of the island of Guernsey, found two skeletons kneeling in opposite directions back to back. The sitting posture is very general in the tombs of the native tribes of America, from one end of the continent to the other. The soil that had been washed into this natural cist in the course of long ages, to which indeed we are indebted for the great preservation of the bones, contained some

portions of an earthen cup, a variety of animal bones and teeth, some of them calcined, and three fragments of flint. Two of these are the remains of implements of the simplest and rudest kinds. One, only three quarters of an inch in length, presents a neatly chipped, narrow, rounded point, the other likewise has an irregular pointed extremity twice as long, and the third is a longer thin flake. Although this latter is unchipped into any useful form, it has still retained a value sufficient to express the sentiment of honour considered due to the dead, and to supply his anticipated wants in the chase of a future life. All these fragments of silex present the dull blanched aspect so general in the barrow flints, the result of calcination. The body had been rudely enclosed in its last resting place by three large flat stones, reaching quite over the sides of the fissure, one piled upon the other; and, the more effectually to ensure security, long flat stones had been inclined over these on either side."

This skeleton in the natural cist may be designated the primary interment, for upon the top of the large flat stones another body had been buried, no doubt at a much later period. This is at once determined by the relics. The objects met with in the cist were all of flint, therefore the burial belonged to the early stone period. With the remains of the second body placed near the surface, which had greatly perished, and had been buried in the primitive flexed or crouching position, were found a finely shaped stone axe, made of granite with the utmost care and skill, pierced with a perfectly round hole nicely drilled through the stone, for a haft, which instrument is of elegant form. Besides this stone axe, there was a dagger blade of bronze covered with verdigris, the handle, probably of wood or bone, having entirely perished, but

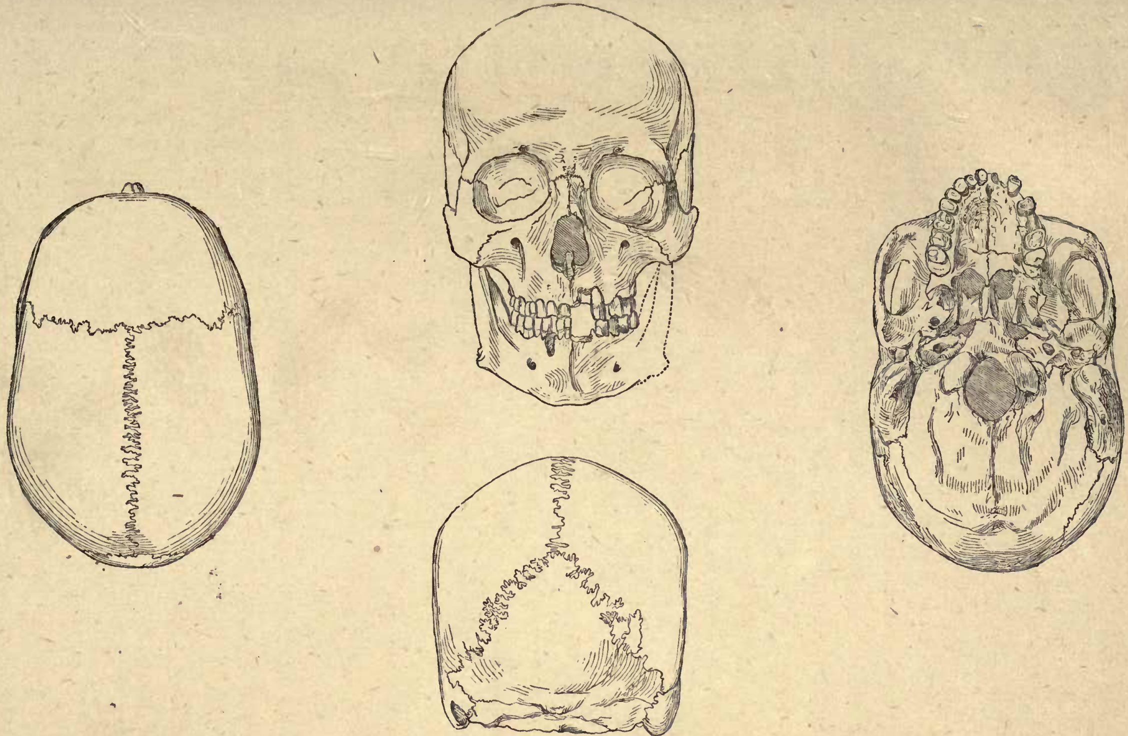
leaving behind the bronze rivets with which it had been affixed. Hence this secondary interment evidently belonged to the later or Bronze period.

The human skulls found in the barrows have afforded the foundations for some of the most decided of the results of barrow digging. The late distinguished Swedish craniologist, Professor Retzius, some years ago saw that the simplest division of skulls, as to their general form, was into two sections, according to their relative length—those which are proportionately long and narrow, or dolichocephalous; and those which are comparatively short and broad, or brachycephalous. Retzius has observed that the various races of man distributed over the world were mostly and in a general manner to be classified under these two sections. The examination of the skulls derived from British barrows soon showed that the great majority of them belonged to the latter class of brachycephalous, or short skulls. But it was found that there are two distinct kinds of barrows in Britain: one of these may be said to be the greater barrows, the other the smaller barrows. In some portions of England, as in Wiltshire and the adjoining counties, the latter are to be occasionally met with, whilst in the Derbyshire, Staffordshire, and Midland districts it is the round barrows that prevail to a very great extent. It has been affirmed by a close observer, who has had a good deal of opportunity of opening the much rarer and much more difficult to explore large barrows, which he has called the long barrows, that the skulls from these interments generally belong to the dolichocephalous or long series, whilst it is universally admitted that the skulls from the smaller or round barrows are distinguished by being short or brachycephalous. Now upon these observations, combined with numerous

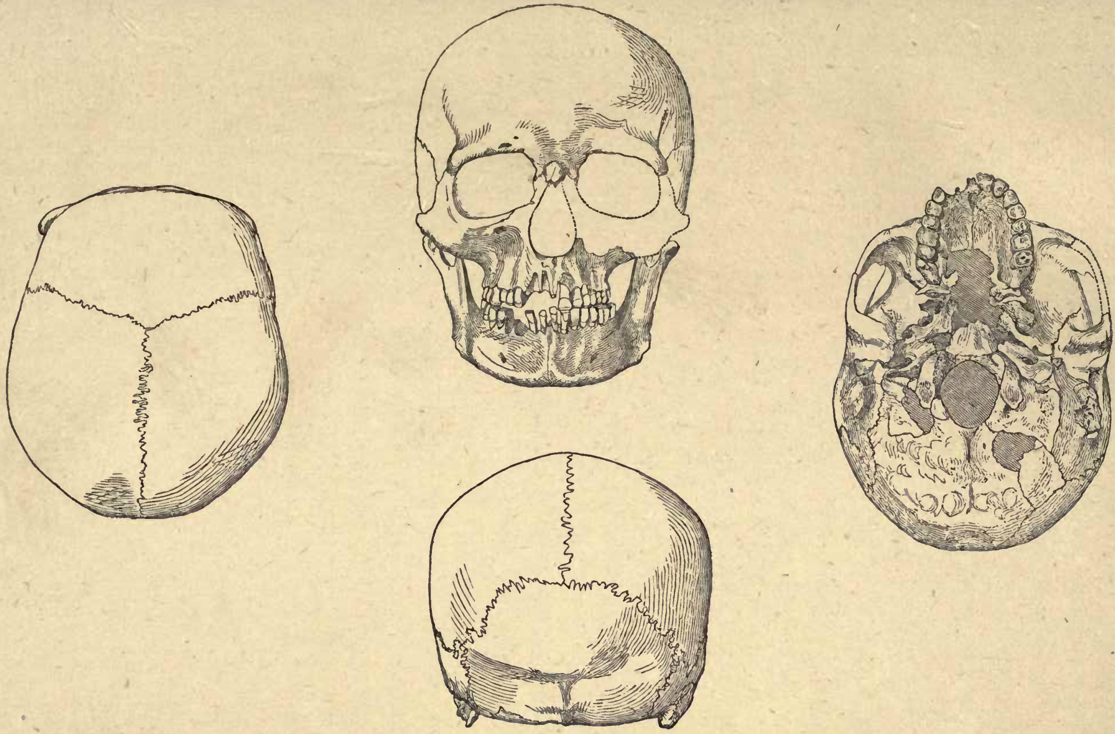
other peculiarities noticed in these two different kinds of barrows, the theory has been founded that these two distinct kinds of barrows were raised by two distinct races of people. It may be premised that the great labour and difficulty of exploring the long barrows stood very much in the way of their thorough and satisfactory investigation. Even the laborious and enthusiastic barrow-digger, Sir Richard Colt Hoare, who worked for so many years and with so much diligence, and also with such great success, in the exploration of the barrows of Wiltshire and the neighbouring counties, did very little with the long barrows, and was a good deal puzzled with them. Still it had been generally surmised, if not admitted, that these long barrows were of great antiquity, that is, more ancient than the round barrows. Such was the opinion of the late Mr. Bateman. Mr. Bateman opened one or two in Derbyshire, which were chambered, or had separate interments divided from each other by slabs of stone. This fact has given rise to the appellation of chambered barrows, which name has also been applied to the long barrows. From one of these long barrows, called Long Low, he obtained a skull of a man which is in good condition. This skull I had lithographed, and the wood-cut (No. 7) of four small figures is here repeated.

It has been represented to me that it would render this paper more instructive if the figures of a short skull from a round barrow of the bronze period were introduced, to indicate the contrasted appearance of the dolichocephalic or long, and the brachycephalic or short skulls. Illustration No. 8 is from another Derbyshire skull.

From the Wiltshire long barrows still longer and narrower skulls have been disinterred.



NO. 7.—ANCIENT BRITISH SKULL FROM LONG LOW BARROW, DERBYSHIRE: QUARTER SIZE.



NO. 8.—ANCIENT BRITISH SKULL FROM HITTER HILL BARROW, DERBYSHIRE: QUARTER SIZE.

Certain facts connected with the long barrows that have been explored lead to the conclusion that they are of a much earlier date than the round barrows. No bronze implements have been met with in these long barrows: nothing but flint implements. Still there is one fact which has always appeared to militate against their greater antiquity—that they really are much larger, more elaborate, and more perfect burial places than the round barrows. The order of sequence in most antiquities usually is for the simpler things to come first, and the more complex and elaborate to come last. But perhaps this objection is not of so much weight. And it is not at all improbable that the long barrows contain the remains of a very early race of people, who inhabited this island before the people who buried their dead in the round barrows.

There are, however, other series of researches of a far more extraordiniary kind, which extend the history of mankind back to a very much earlier period than that in which the first barrow was raised in the British Islands. The subject of these curious researches is very extensive and can only be glanced at in a few words on the present occasion. It may be characterised generally as geological and palæontological, and is constantly to be taken up and pursued in connection with human remains and the works and implements made by man which have been preserved. No one can explain these researches better than Mr. Garner, and it is almost necessary to apologize for introducing any allusion to them here.

The wrought flint implements that are met with in barrows are of two kinds—one those in which the flint is simply chipped into the desired form, and the other in which the flint, after being chipped into shape, has after-

wards been ground to a smooth and often polished surface. The former kind has clearly preceded the latter, which belongs to a much later period, when the primitive arts had been advanced. But the researches of M. Bouchet de Perthes and others in the drift and high-lying gravels about St. Acheul and other parts of the north of France led to the discovery of a considerable number of large rudely-chipped flint implements, which are distinct in form from the implements of the barrows. These have been named the drift flints, and some of them had actually been discovered and described in England, although the fact was unnoticed and forgotten, many years ago. At first and for some time it was disputed whether these rude flints had not been produced by natural causes, and not by the hand of man.

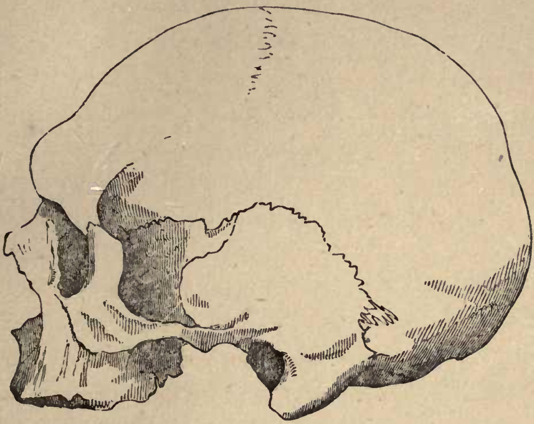
More extended researches revealed the fact that these flints were to be met with in many places in England and in France, where the remains of these very ancient gravels had been washed by rivers that had flowed over them at the most ancient period of time. To give some idea of the lapse of years that must have passed, it may be mentioned that these drift flints often occur among gravels that are now at least 300 feet above the levels of the present streams. The water has slowly washed for itself a course at least 300 feet in depth through the strata which intervene. Another thing which confirms the vast antiquity of these drift gravels, is the discovery in them of the bones of long-extinct animals, such as the mammoth *(elephas primigenius,)* and hippopotamus. More extended researches have revealed the remarkable fact that the river drift flints, whether they are met with in the north of France, where they occur in many different districts, or in the south of England, where they have been collected in dif-

ferent counties, when compared with one another have a singular agreement in form. So much is this the case that there are two or three chief forms of these drift flints which agree wherever they are met with.

During the investigations of the drift gravels, there was for a long time the objection made to the vast antiquity of man, which was claimed by those who asserted that these rude flint implements were the work of human hands, that no bones of man had been met with among these deposits. This certainly was a weighty and almost inexplicable objection. But at the same time as these investigations were going on in the drift gravels other inquirers were engaged in exploring the different limestone and other caverns which occur in many parts of Europe, and in which there are striking evidences of the residence of man during the most remote periods, when the human race was in its infancy. Besides the stone implements used by man which were found in these caverns at different depths, often absolutely sealed up by layers of stalagmite, some of which implements corresponded very closely with those from the drift gravels, there were also met with, intermingled with the teeth and other bones of numerous extinct animals, such as the great cave bear, the cave lion, the hyæna, the reindeer, &c., bone implements formed by human hands, some of which actually have sketched upon them even not unartistical drawings of extinct animals, such as the mammoth—and lastly, most conclusive of all, human skeletons. So that the old objection, which led to doubts concerning the true interpretation of the river gravels, is now finally and for ever disposed of. Man's antiquity is carried back, without the slightest ground for doubt or dispute, to periods vastly too remote to be measured by any save geological epochs.

It is not necessary to mention all the places in which the osteological proofs of primeval men have been discovered. One or two may be instanced. The skeleton met with in the cave of Cro-Magnon, in the valley of the Vezere, in the south of France, is now in Paris. Also there is another skeleton of a man in the same museum which has been discovered in a cave near Mentone, in Italy. I wish particularly to point out that both these skeletons contradict the hypothesis of my late distinguished friend Professor Retzius, who considered that the earliest inhabitants of Europe were little people, had brachycephalic skulls, and were by successive waves of fresh comers driven westward, so that the present representatives of these primeval people are the Basques, and the Finns, and the Lapps. These cave skeletons are not short, but actually tall, of nearly six feet in stature, and their skulls are nearly dolichocephalic. A few years ago, when the Neanderthal skull was discovered in a cave in Germany, which could only be approached by climbing up a perpendicular rock a considerable height, Professor Huxley and some other such hypothetical reasoners greedily caught hold of it to support their delusive notion, that man is derived primarily from the anthropomorphous apes. This skull was said to prove the truth of this dream, and to come between the ape and man, in fact, to be the long lost and the long and anxiously inquired for "missing link." At that time I had the gratification to prove to many men of science that the Neanderthal skull was nothing more than a skull of anomalous development, such as occasionally occurs among all human races, even in Englishmen, and that so far from supporting the doctrine of gradual development of brain and mental power, it had a brain actually larger than the general size of the brain in any of the civilized

races of Europe, standing in need of no development whatever.*



No. 9.—LARGE SKULL OF AN ENGLISHMAN, SHOWING A NEANDERTHALOID DEVELOPMENT. IN MY OWN COLLECTION.

The Neanderthal skull has actually been assumed of late by two eminent French craniologists to be the representative type of the first and most ancient prehistoric race of man. This view is based upon hypothetical reasonings, and stands in the face of the undeniable fact of the colossal size of the skull, and necessarily, of the brain of the man whose remains were found in the Neanderthal cave.

* The Neanderthal Skull: its peculiar conformation explained anatomically. By Joseph Barnard Davis, M.D. Memoirs of the Anthropological Society. I. 281.

RAMBLING THOUGHTS IN A HANLEY MARL PIT.

BY J. E. DAVIS.

I SEE by the notice issued convening this special meeting of the North Staffordshire Naturalists' Field Club that the spot on which we are assembled is described as Messrs. Hampton's "marl works." "What is marl?" is a question you may naturally ask. Stumbling at the very threshold, I at once confess I cannot tell you. The reason I cannot tell you is that the word is applied in various places to very different substances. If you ramble a few miles to the south-west, on the Shropshire border of Staffordshire, you will see in the middle of red fields large hollow places or pits, now covered with brushwood and trees. If you inquire, you are told they are marl holes, whence in former days marl was taken and spread upon the adjacent land as manure. There is not the slightest resemblance, geologically or chemically, as far as I am aware, between the red so-called marl of that district and the light bluish-grey marl now before us. I do not wish to under-rate the value of the marl works to the owner or his lessees, but I apprehend that it would be a farm of very peculiar character whose fields would be improved by, and a farmer of equally peculiar views who would desire to see them covered by, a dressing of the raw material on which we are standing. In other parts of England you will find clays and sands, very different from either this light clay or the red clay I have mentioned, also

called marl, and therefore you will understand why the term marl is difficult of definition. It is in fact often applied without definite scientific meaning. We shall have some better idea of it by describing this rock, or clay, or stuff, as "mudstone."

The great majority of our rocks may be described as made up either of mud, or of sand, or of gravel, just as we find on the sea-coast now either mud, or sand, or gravel. At our watering places we find sand or gravel,—sand at New Brighton and Rhyl, and Barmouth and Borth,—gravel at Llandudno and Aberystwith. We do not see much of mud at fashionable watering places, for the simple reason that a mud coast is not very agreeable. Where there are no shells or pebbles, but every step you take you sink into mud, is not chosen for lodging-houses and hotels. There is plenty of that description of coast, however, in various parts of our island, on the east especially. Take the Lincolnshire coast for example; from Boston northwards to Great Grimsby you may at low water walk over miles and miles of mud, not unlike the hardened mud we are now standing upon, which was itself undoubtedly at one time a line of coast—either an actual sea coast, or not far removed from the sea, just as in the same way our rocks of gravel called "conglomerates" and our rocks of sand were also formerly sea beaches.

Let us look at this accumulation of mud a little more closely, and take advantage of the cutting made in clearing it away, presenting what is termed a "section." Here we see actually before our eyes what we only generally see and know by means of a geological section on paper. What is it we see beyond the mere slice or face of mud-

stone, as I have termed it? Why we see lines, not flat, or straight, or horizontal lines, but sloping, slanting lines. These lines are the lines of stratification; in other words, the line of deposit of the sediment as it settled down from the water. We shall have something more to say about these lines presently, but I must ask you now to direct your eyes to this pillar before me. What is it? A trunk of a tree. How came it here? Well, it is to endeavour to answer that question that I am occupying your attention this evening.

To every one of you to whom I have the honour of speaking it is, I doubt not, familiar knowledge that in hard rocks, however far removed from the present sea coast, and however high above the sea level they may be, on the summit of Snowdon or high on the Alps, we find shells embedded in the rocks under such circumstances and in such profusion as to leave no doubt whatever of the rocks having been formed under sea water—the natural deduction at first sight being that the sea once attained those high levels, more matured observations leading, however, to the inevitable conclusion that the rocks were deposited at a lower level, and have since by various causes, operating through enormous periods of time, been raised to dry land and to their present elevation.

However wonderful and startling these deductions may be, there is an obvious analogy between the shells in a sandstone rock and the experience of a walk along the sands of the present sea shore, covered more or less profusely with shells. But if you will condescend to a careful hand-to-eye observation of the mudstone around us, while you will scarcely meet with a shell, you will find abundant unmistakable traces of plants, some large remains

of apparent trees, others of delicate ferns, quite distinct from the only traces of vegetation we ordinarily find on the sea coast, namely the sea weeds. The remains we find here tell us rather of land than of water. You will notice that the outside — we will call it the bark—of this great trunk or stem is black. That is the effect of a chemical change, carbonizing the vegetable rind.

I will now call your attention to something out of our present sight. You see that opening partly covered up, a few yards from this trunk. That is the trace of burrowings in the ground of a curious animal in search of a black substance lying only a few feet beneath us, and a foot or two thick, spread out in parallel lines corresponding with the lines of bedding now visible to us, and to which I have already called your attention. The substance is coal, and the animal in search of it was man. Below that again is more clay, and then another bed of coal, and so on to a great depth we should find beds of clay and sandstone alternating with beds of coal, varying in thickness, the whole of these beds forming what are termed the coal measures. One of the upper imperfect beds you see above us in that dark band across the face of the cliff. Although in our ordinary house coal we cannot, however sharply we may scrutinise the contents of the coal scuttle or the ashes in the grate, see anything like plants or trees, it is now established beyond dispute that coal is of vegetable origin, mineralised and carbonised. We find in the intervening clays and sandstone beds clear remains of trees and plants, simply showing that the transformation there has from one cause or another not been complete. There is enough evidence left to disclose the tale as to the rest.

Under what circumstances did this accumulation of vegetable matter take place? I have already said we cannot trace anything like it in an ordinary ramble on the sea shore. You may smile if I ask you to come with me to a quiet country fish-pool for a lesson on coal-making. Look, however, at the bottom of a fish-pool in a dingle of coppice wood, when the water has been drawn off for the purpose of clearing it out or catching the fish: you will generally see a mass of black sticks and leaves, a few inches thick, lying on the mud below, and if you look carefully you may often, under such circumstances, see traces of successive layers of black leaves, with a few inches of mud between the accumulations of successive autumnal falls and winter floods. In this operation of nature on a minute scale, in the collection of vegetable matter in the hollow of a fish-pool, you may acquire an excellent idea of how coal has been deposited in large basins, such for example as that of North Staffordshire. If you will not condescend to so simple an illustration, perhaps you will, when travelling by the railroad between Stoke and Leek, so far oblige me as to put aside your newspaper or your gossip for a few moments after crossing the canal at Stockton Brook, and look at the sides of the railway in the cutting between that place and Endon Station, and you will there see a layer of prostrate trunks and branches of trees. That is a sort of half-way house in the process of coal formation, when the valley was filled with water—it may be a lake or a river flowing sluggishly through it.

But if we travel further afield we shall find analagous operations of nature on a scale sufficiently large to satisfy you. The narratives of Franklin and Back, and especially Richardson, in the Polar regions, inform us that the rivers are there constantly transporting wood and plants, some-

times heaping them up in the large fresh-water lakes and embayed sea openings which occupy large portions of that continent (larger than any of our coal-fields); at other times sweeping them out to the open sea and lodging them upon its shores. Descending towards the south of the great continent of North America, we learn from Captain Basil Hall, confirmed by subsequent observations, that similar accumulations are constantly taking place towards the mouth of the Mississippi, while the frightful accidents to steamboats, so repeatedly occurring higher up that river and its tributary, the Ohio, from the concealed "snags," attest the continued deposit of large trees, brought down in flood time, and partially buried in the mud, simultaneously deposited by the turbid waters.

But this trunk, standing on its end, speaks of something besides drifted materials in flood-time. It tells of a quiet, gradual submersion of trees on the spot, so gradual that the trees have not been overturned, but died and were buried on the spot where they flourished. If this were the only specimen, indeed, found in this position it might be supposed that that position was accidental, and that the tree might nevertheless have been drifted far away from its birthplace, retaining or regaining its original position as it grew, but a number of other stems in the same position found in this pit, as well as observations in other coalfields, tell us in unmistakable language that this fine fellow met his end and was buried in his native soil.

But we must not be misled, and suppose from the size that I am pronouncing the funeral oration of an ancient monarch of the forest. I am not mourning over a venerable cedar or slow-growing oak. I am rather looking at a broken reed. It is a calamite, and it is no calumny

to say that the calamites were all fast livers.* They drank, I mean imbibed, a good deal, probably led into the habit by the stigmariæ, a family of doubtful character, who drank to such an extent that you will not be surprised to hear that they were usually under water, and are now probably extinct. The calamites, moreover, like many fast young ladies and gentlemen of the present day, were so decidedly horsy as to be supposed by M. Brongniart to have been allied to the equisetacæ. Very degenerate representatives now exist only a few feet in height, and with stems even in tropical regions of only an inch in diameter.

But I must leave these dry botanical descriptions and definitions, and say a word or two on the supposed conditions under which these materials for coal were deposited. The luxuriant vegetation of the coal period has been supposed to indicate a moist atmosphere and warm climate, for the large succulent plants and arborescent ferns which abound in the coal measures could only, it has been thought, have grown to their vast size with much moisture, and an atmosphere so moist could alone be obtained in a hot climate. At one time it was thought that the existence of such a climate at a former period in these latitudes, known now only within the tropics, necessarily involved a wholly distinct condition of things throughout the globe to that existing in the present day. Careful observations, however, conducted in a philosophical manner, now point to this result, that the same laws of nature then obtained and the same causes were then in force as at the present period, and that changes of climate fully sufficient to

* Note.—It will be seen by Mr. Ward's paper, following the present, that he has settled that the fossil is not a calamite. Not doubting the accuracy of that determination, the observations are left in the text as delivered.

account for the variation in vegetable and animal life may have been mainly the result of changes in the relative position of land and water, and that those changes were extremely gradual, causing, however, peculiarities in every coal basin or field, so that in fact they have been accumulated under different conditions.

Many of our larger coalfields appear from the admixture of marine shells and animals with land plants to have been probably formed on the shores of an open sea, or in bays of salt water, into which plants had been drifted from the adjacent lands ; others, as that of coal brushwood, at the mouth of a former large river ; and some of smaller area, being charged with remains exclusively of terrestrial or fresh-water origin, are supposed to have been formed by rivers emptying themselves into lakes. The small field of Shrewsbury is an illustration of this last mode of formation. I shall not stop to discuss the evidence as to the conditions which obtained during the accumulations of the beds forming the North Staffordshire coal-field. There are many members of our society far more conversant with the data necessary to form an opinion on this point ; but I am probably not doing an injustice to any one in especially mentioning the name of one of our number, Mr. John Ward, as one thoroughly conversant with this question. The fossils so diligently collected by him and by Mr. Molyneux and others point apparently to sea water predominating through the greater part of the period, but with a large admixture of fresh water towards the close. I will only say that every coal-field or basin has its own peculiar features. The beds of coal vary everywhere in number and thickness, as do the intervening beds of mud, or clay, and sand. You have heard in South Staffordshire of the ten-yard coal, where

a series of deposits of coal have taken place without any intervening clays or sands. As the beds vary in every district, so are they known by local names.

I must, however, detain you a few minutes longer, while I say something as to the mode in which these coal-beds have been brought into their present position, a part of the subject that to persons who have not made the history of our earth a study is, I believe, difficult to realise. Some of you may say, "I can understand how coal was formed at the bottom of inland lakes, or bays in the sea, and covered over by mud and sand; but how has it got here, far away from the sea, and on high ground? I should have rather looked for it low down in the valley, at Trentham, than in an elevated position."

My dear sir, or madam, it is true you and I now stand high in the world, nearly half-way to Hanley, and can look down on Stoke and Joiner's-square. That is very satisfactory, no doubt; but it was not always thus. In order to comprehend these great changes, you must get rid of all these notions of irregularities. Those pretty valleys of the Trent and its tributaries were unknown to the old fish who, Mr. Ward tells us, lived in those olden times. These valleys are but the scoopings of yesterday, as compared with the remote antiquity of the mudstone on which we stand and the coal under our feet. You must endeavour to realize the whole of the present valleys filled with this mudstone, or clay, or marl, or whatever you like to call it, across to the top of Wetley Moor, far and far away to the east; and to Silverdale, far, far away to the west and high above the tops of those beautiful chimney-stacks which adorn the landscape, and the whole of the district, down, far down, thrown, it may be, be-

low the level of the sea. You must endeavour to realize a succession of gradual sinkings or depressions into deep water, alternating with gradual emergings into shallows, and eventually a gradual continued lifting of the whole district, converting into what we, with our necessarily inadequate perceptive powers, are inclined to speak of as permanent dry land.

The gradual, but I believe, certain rise of the whole Scandinavian coast going on at the present moment, although amounting to only a few inches in centuries (and to be the subject of fresh observations, as I see by the proceedings of the British Association last week) gives only a faint notion of the extremely gradual nature of these great changes, the time employed in which is, I firmly believe, inadequately represented by millions or billions of years. Not, however, but that there are indications, and even in the section before us, of other causes of disturbance in the relative change of level since the deposit under water of the coal measures, and it is in reference to these indications that our friend the calamite affords the most interesting testimony.

Almost at the commencement of my observations I pointed out to you the lines of stratification in this section. I need not tell you that in accordance with the universal law of gravitation water at rest is at a level line—the sea, for example, on a calm day. For the same reason sediment equally diffused through it naturally settles down in even lines or beds. The action of the tide, however, washing up the sands on the shore, gives it, as you know, a slight inclination, so that you walk down a slope towards the sea, or in it when bathing. The angle before us is not greater than what we see on a coast line. On

the other hand we know that the strata or beds of rock, including coal, are often found at a much greater angle, that is to say, more highly inclined, or steep, quite inconsistent with the notion of their having been so deposited. In those cases, beyond a doubt, some great disturbance has taken place since the rocks formed at the bed of the sea. There have been sudden upheavals by earthquakes, or volcanic action at some period or another, throwing the rocks out of their original level or nearly level line.

In the case before us, however, and if we had no other means of forming an opinion but by an examination of this pit, is there anything to tell us whether that line of stratification is the original line of the mud, bounding the lake in which it was formed, or whether it has been tilted since? What does this calamite stem tell us? You see it leans. It has not been disturbed by the workmen, we may be sure. It would have tumbled to pieces if it had, and you may examine the base and satisfy yourself on that point. How does it lean? It leans with the dip of the bed, and at a corresponding angle. Now you know that all trees, but especially fast-growing trees—larch, for example—shoot up straight, and that it makes no difference, in this respect, whether they grow on a bank or on a flat field. Therefore, if this calamite had grown on a slope, it would still have shot upwards in a line perpendicular to the horizon. As we see it, it is not perpendicular to the horizon, but it is perpendicular to or at right angles with the dip. That is just the position we should find it in if the bed had been originally horizontal, and had been tilted since the tree grew and the land had accumulated round it.

If we had only this one specimen as a guide it would

not be safe to come to a positive conclusion on the subject, but when I was here three weeks ago there was a younger calamite standing a few feet off with an inclination precisely parallel with this stem of larger growth. That confirmatory evidence, the absence of which I deplore this evening, coupled with the statement of the Messrs. Hampton, the lessees, as to the similar inclination of other stems would leave no doubt in my mind that the inclination of the bed is due to a subsequent disturbing force. All doubt is removed when we combine the knowledge of the general structure of the North Stafford coal-field, affording indisputable evidence of disturbing influences subsequent to the deposit and consolidation of the beds.

Time compels me to conclude. Perhaps it is as well, for if I proceeded it would have been my painful duty to call your attention to certain faults in the strata, for alas, this clay, like the human, has its faults as well as its virtues. Let us for once reverse the supposed associations of the tea-table, and as

> "From silver spouts the grateful liquors glide,
> White china earth receives the smoking tide,"

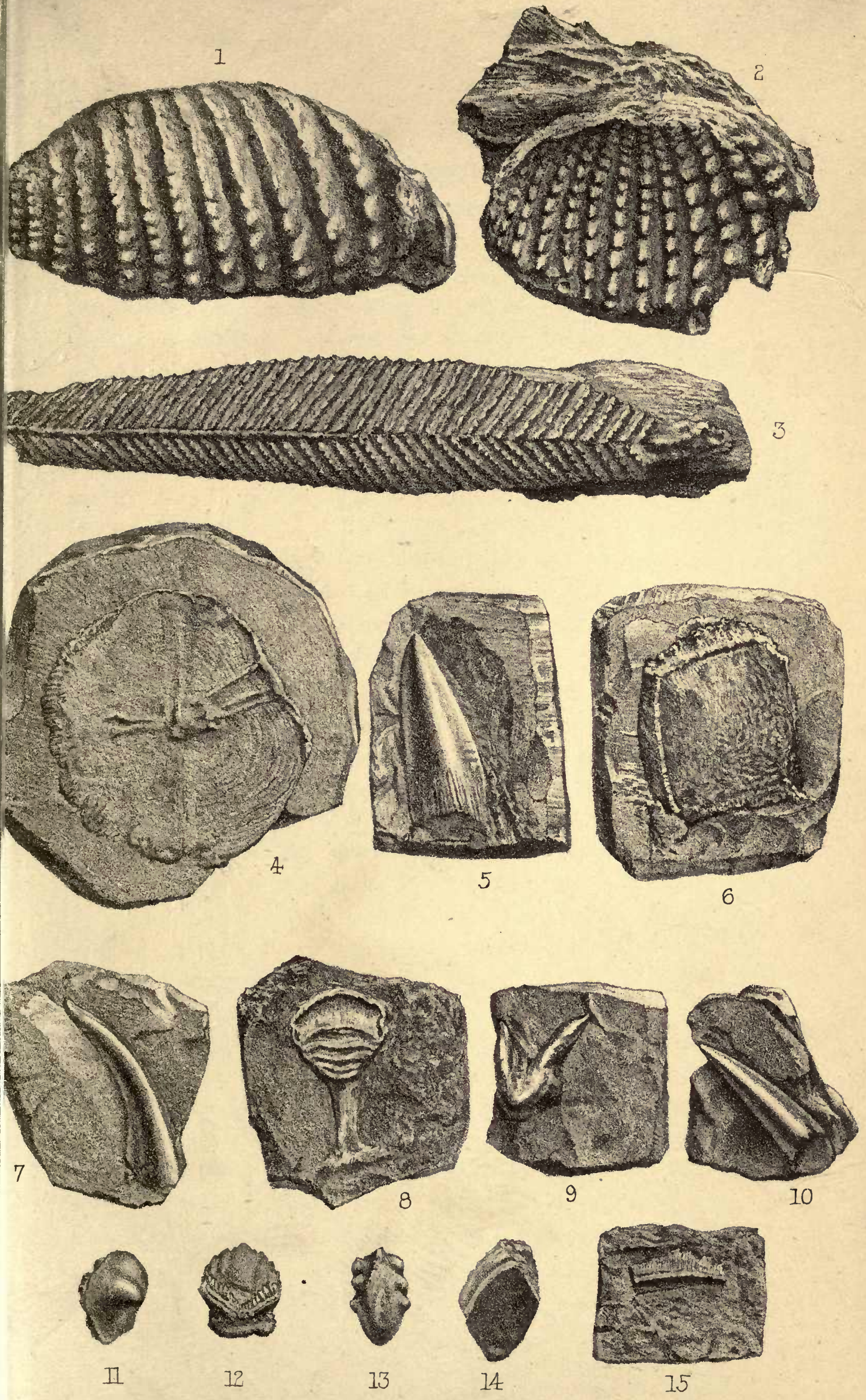
let us drown all ideas of faults in a cup of that grateful fluid so kindly supplied by the hospitality of our host and hostess.

NOTES ON THE FOSSIL TREES IN A MARL PIT AT HANLEY.

BY JOHN WARD.

THE geological position of the beds of marl in which these trees were found is the upper middle or Pottery division of the North Staffordshire coal-field. They appear to lie between the gutter or Fenton Low coal and the bassy mine ironstone. They bear a close resemblance to what is commonly known in this district as the peacock marl, so called from lying close to a bed of coal called the peacock coal, which takes its name from its iridescence, which is supposed to resemble the feathers of the peacock. This bed of coal is very general in the Pottery coal-field, and affords an excellent datum-line to the over-lying strata. In the marl pit there are two beds of coal, both of which are of little commercial value.

The large specimen which was standing erect was discovered in the summer of 1867. My attention was directed to it by a paragraph I saw in the *Staffordshire Advertiser*, in the month of June in that year. At that period about two feet of the fossil was exposed. I was informed by the workmen that some six or seven feet had then been broken away before its true character had been discovered. This was fully borne out by the impression left in the marl against which it had lain. From the time it was first discovered up to the time we saw it, it



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must have measured eighteen feet in height and a little over nine feet in circumference. Although I have examined this specimen closely, I have failed to discover any trace of the roots. The swollen base alone indicates their commencement, but as it appears to rest on a bed of coal I infer that the roots have become carbonized.

The exterior surface of the fosssil is covered with a thin coating of coal about a quarter of an inch thick. Under this I noticed fine longitudinal lines, but I have not succeeded in finding any scars.

On the north side of the fossil I pointed out to some of the members present a deep longitudinal depression which commenced near the base and extended the whole height of the fossil, and probably went much higher. There is something very peculiar in this depression. You must bear in mind that this is not an isolated case. I have frequently noticed them before, and other observers have recorded similar depressions. An eminent authority has suggested to me that these depressions were caused by the falling of the internal cylinder (which, like the outer cylinder, was of a hard nature) against the outer cylinder or shell, which would cause it to bulge out the outside towards which it fell, and cause a hollow inwards on the contrary side.

The second specimen, or No. 2, which was lying on the ground a short distance from the erect one, presented much the same appearance as No. 1. On examining the place where it had stood, I saw distinct marks of stigmaria, and I have no doubt that they belonged to this tree.

Around these trees I noticed a considerable quantity of

fossil plants, and I am informed that the heap of calamites from which the members collected so many fine specimens during our visit to the marl pit were all found in the marl which surrounded the base of these trees.

Most of the members present to-night will remember the interesting and elaborate paper on these trees which Mr. Davis read during the visit which the club made to the marl pit in September last. The author of the paper described the trees as calamites. This I think is an error, although, as I have before said, I have failed to discover the roots so characteristic of sigillaria. Yet I believe we have sufficient evidence to prove that they are undoubted specimens of that genus.

I will briefly detail to you the internal structure of sigillaria and stigmaria. This structure is very peculiar, and specimens showing structure are very interesting objects for the microscope when properly cut and mounted. Mr. Binney (who you will remember was the first discoverer of the true character of stigmaria, and its association to sigillaria) says, in his description of these plants, "that after the discovery of the outer radiating cylinder by Witham, in lepidondendron, and the same arrangement by Brongniart, it was to be expected that an outer radiating cylinder would be found in stigmaria, if it were the root of sigillaria." He then goes on to say that after examining a large number of specimens he finds clear evidence of this outer radiating cylinder in stigmaria. "Not only," he says, "had it an outer but an inner cylinder. There appeared to have been on the outside of this inner cylinder bundles of vessels which communicated with the rootlets. The bell-shaped orifices from which the rootlets spring are well displayed, and the space be-

tween them is occupied by wedge-shaped masses of tubes, or elongated utricles arranged in radiating series." This structure, he says, clearly proves that stigmaria is the root of sigillaria. So much for stigmaria. Sigillaria he describes as having "an inner radiating cylinder composed of barred vessels, a space occupied by lax cellular tissue, and an outer radiating cylinder composed of tubes or elongated utricles. The broad space intervening between the internal and external cylinders was filled with a lax cellular tissue, and traversed by medullary bundles communicating with the leaves on the outside of the stem." This structure was most beautifully shown in a small specimen of sigillaria which I presented to him, and which he has figured and described in the Transactions of the Manchester Philosophical Society, to which I must refer you for a more detailed account.

Some of you will remember that the No. 2 specimen, which lay some little distance from the erect one, had a stem or cylinder of a few inches in diameter passing down the centre of the tree. I broke away a portion of this cylinder. Not feeling satisfied as to its true character, I sent it to Mr. Binney, who at once recognised it as the central axis or inner radiating cylinder of a sigillaria, such as he describes this plant as possessing. On examining the erect specimen I found that on the north side a portion of the outer cylinder had fallen away, and a stem or cylinder exactly agreeing with that in No. 2 was clearly visible.

Here, then, I think we have ample evidence that the two fossils were not calamites, as supposed, but sigillariæ.

I think there can be no doubt that these trees grew

and died on the identical spot we saw them standing on. They could not have been drifted into the position in which we saw them: if they had we should naturally expect to find evidence in the marl in which they were entombed. After a careful examination I cannot arrive at any other conclusion than that the marl in which they were enveloped is nothing more than sediment quietly and tranquilly deposited in water.

Assuming, then, that these trees grew on the spot we saw them standing on, let us suppose that the bed on which they stood was raised above the surface of the water as an extensive plain: this would gradually settle down and become submerged: it would then become covered with the sediment which was being deposited from the turbid waters, and gradually covered up. This sediment accumulated until a new surface was formed. Here, then, another forest of plants and trees would grow. Then an interval of rest, and one of the beds of coal which you saw in the marl pit would be formed. The same process as before would then go on, and the second bed of coal would be formed; and so similar intervals of repose, with occasional subsidences, would be repeated until the whole of the seventy or eighty feet of strata we saw was deposited.

But if for the formation of this eighty feet of strata so many changes and intervals of repose were required, what, I ask, must have been the changes which have taken place during the deposition of the strata which compose the North Staffordshire coalfield? In this coalfield we have, according to Mr. Hull, some thirty beds of workable coal, besides a great number of thin beds which are distributed throughout some 5,000 or 6,000 feet of strata. Each of these beds represents so many breaks or periods of repose.

The enormous aggregate depth of the whole of the coal-bearing strata in this coalfield, taken together with the thickness of many of the beds, clearly proves that a long period of time must have been required for its formation. A recent writer of some note has asserted that it is impossible to suppose that our coal measures accumulated more than one-tenth of an inch in a year. If this is true, what a prodigious amount of time would be required for the deposition of the eighty feet of strata in the marl pit! But if for the formation of this thin slice of our coalfield such an amount of time was required, what, I ask, would be required for the deposition of 6,000 feet? Who amongst us can tell? It can only be known to Him to whom a day is as a thousand years and a thousand years as a day.

The soft internal structure of the interior of these trees appears to have decayed away, and the trees to have become, as I have said, partially immersed. The tops and branches would be exposed to the storms of that period, and fall away. The sediment would all the time be depositing around them and so cover them up. By the action of the gases the bark of the trees would become carbonized, and the thin shell of coal we saw on them would be formed. The interior of the trees would now become filled with the sediment, and the ferns, calamites, and other exuviæ of the carboniferous period would be drifted into them and covered by the sediment. Frequently small reptiles crept into the interiors and were thus entombed. Dr. Dawson has found a number of these creatures in the interiors of the erect sigillaria in Nova Scotia, and several species of land shells.

Some doubt appears to exist as to what kind of a fruit belonged to sigillaria. It is generally thought that the

fossil known to us as trigonacarpon was the fruit of this plant. I hold in my hand a portion of one of them which Mr. Hampton found in the interior of one of the trees.

Had time permitted I might have told you something respecting the curious fishes which lived in the ancient carboniferous seas. Judging from the vast quantity of remains we find in this district, the waters would appear to have swarmed with animal life. Fishes of strange forms, and very different from what we are accustomed to see at the present day, sported amongst the calamites or basked in the shade of the sigillaria.

LINES ON A FOSSIL TREE.*

BY ROBERT GARNER, F.L.S.

THOU sered and shattered wreck of time untold!
Low let me bow, and awestruck ask of thee,
Like Augur at Dodona's oak so old,
To tell—the bye-gone, not futurity.

Old! said I? What compared with thee is so?
Not grove Thessalian, nor, perforce, of fate
The mystic tree in Eden that did grow,
Nor gophir, unknown wood; these all are late—

Late in creation's eve. Older thou art,
Weird form, than paradise, than man, than sin.
Ther're tongues in trees, they say; then now impart
Somewhat of ancient times; come speak! begin,

Older than mountain chain—than Mow or Cloud,
Than Alp or Jura—dead and buried thou,
Long e'er they rose; though, with them rising, bowed
And tilted rudely was thy butt I trow.

* NOTE BY THE AUTHOR.—The members of the North Staffordshire Naturalists' Field Club were entertained by Mr. R. Stevenson in a vast amphitheatre on his property at Hanley, formed by an excavation for the extraction of the fire-clay of the upper coal measures. At the bottom stood the stock of a large fossil tree, perhaps a sigillaria, which the workmen had laid bare, and near were tables spread for the entertainment of the numerous party. Mr. J. E. Davis, stipendiary magistrate, whose name is not unknown to Silurian geologists, delivered an interesting and eloquent address.

Hast thou no tongue, no speech ? Thou "must be read."
Then now I cleave thee with this steel and maul ;
Thou should'st have stood in learned hall instead—
Thou wilt ? Then speak, old stock ! We listen all.

"Call me not old : I'm but of yesterday.
Deep rocks below long ancestry imbed.
'Paternal or maternal,' do you say ?
Our kind no sexes knows : we're better bred :

Nor call me Calamite, ill-omen'd name !
Stigmaria if you like, but that's my root.
You mean no stigma ! but if all the same,
These scars would Sigillaria better suit.

But pardon, thou of brow and eye of thought !
I scárce can tell you whence my native soil,
But there profuse plants of primeval sort
Gigantic sprung, nor needed care or toil.

Around that land stretched ocean clear and deep,
And gently rippled on the sparkling shore :
There coral-polyp built the atoll steep,
And pearly conch and clam bedeckt its floor ;

And there I flourished ; like an orient fan
My branches spread ; lofty and straight, like beam
Of setting sun : his course as now he ran,
But seldom through the gloomy shades could beam.

My life a pleasant dose, all undisturbed,
Save by the hum of insect, or the splash
Of megalichthys, or more rare perturbed
By glare from that far peak—with quake or crash.

I died! but long I stood, a hollow bole
In which died leaves and reptiles; but anon
I sunk, I sunk, and turned without to coal,
Within to stone: I deemed my semblance gone.

Deeper and deeper! there I lay entombed—
How long were useless, being of to day,
To tell thee: but these æons long were doomed
At their appointed hour to pass away.

Oceans have lashed above my buried frame,
Strata been spread, and towering cliffs upreared,
Monsters of varied kind and form and name
Successive all have been and disappeared.

I rise—I rise! denuding waters rush
Some twenty fathoms only o'er my head;
Listen! was that a glacier's grinding crush,
Or iceberg showering from its melting bed?

Since then, a score millennia only, Sir;
Now tramped the mammoth, but I could not hear;
No light can pierce, no force my burden stir—
Ah! what a shock! that blast was surely near.

All hail, thou being that hast me exhumed!
Take what thou want'st—thy iron, and calc, and coal,
And clay t'employ those wondrous hands—entombed
In it I've been full long—they're thine, the whole.

But tell me what those forms, than thee more fair?
At sight of them my flinty bosom warms,
And almost sprout again my ribs so bare,
'Post-pliocenes'? you joke; ah well, earth still hath charms!"

Hail thou! the mighty relic of the world
Yet young; libations we will pour to thee;
Not juice of vine in noisy riot purled,
But wise men's sober beverage—best Bohea;

With cream (not of bos priscus), and the sweet
That flows from better cane than calamite;
And these and more do gentle fingers mete
Deep in thy out-dug bed, on wide-spread board so white.

A SKETCH OF OLD NEWCASTLE.

BY THE REV. J. S. BROAD, M.A.

I AM afraid there is nothing of very special or romantic interest in the history of our old borough, and certainly our antiquarian relics are but few. Still, it *is* an old borough, and it has a connection with several individuals of note, who figure in the annals of our country. Hence it is not without interest to those, at least, whose lives and labours have been identified with it. There is something tantalizing in the name Newcastle: it should now be, as far as age is concerned, Oldcastle, or, still more correctly, No-castle. Like its more gigantic namesake in Northumberland, whose grand, massive keep, begrimed with the marks of time and the still more recent smoke of our manufacturing age, carries us back some hundreds of years, our Newcastle presupposes an older castle, but the old and the new are alike among the things that were. I need not tell you that the only trace of the castle at present is its site. One of our townsmen (Mr. Thomas Ward) says "traces of an underground room—a small square chamber of hewn stone on the Castle Hill or mound—were visible in (and possibly after) 1805, and were seen by me." If this was part of the castle, it has disappeared and we are left to conjecture what kind of a structure our stronghold was from a quaint description of it which I shall presently read, and perhaps from the rude sketch forming the borough arms and seal. But what is the

meaning of the appendage, "under-Lyme," which distinguishes our town from Newcastle-upon-Tyne? It is often written by outsiders Lyne, and Line, but this is simply a mistake: old charters and documents spell it Lyme; and the most probable explanation is—Newcastle under the forest of Lyme. Not, indeed, the forest of limes, or linden trees (as has been said), but the forest boundary—the word lime (from *limes*, a boundary.) An old monkish writer says that the county of Chester is shut in from the south of England by the wood lime. Thus, Lyme Handley, in that county (a seat of the Leighs, near Macclesfield) is said to be so called from being on the limes or border of Cheshire. The forest may be traced through a line of country in which the names of several places indicate the course, bringing us to Audlem (Old Lime, or Aldelime, as in Domesday book), at the other extremity from Lyme Handley or End-ley, the ley or pasture at the end of the lime or boundary. This is confirmed by such expressions as Chesterton-under-Lyme, Madeley-under-Lyme, and Whitmore-under-Lyme, formerly used; all being under or beyond the lime, or "extra leniam" as it is expressed in a charter of Randle de Blonderville, Earl Palatine of Chester, who at the time held the Manor of Newcastle, which was beyond the border of his own county.

I have spoken of the name before giving any account of the rise or beginning of the town and castle bearing the name; but this need not mislead us. On this point, as well as with regard to the origin of the name, there has been some uncertainty. That it was called Newcastle, in contradistinction to Chesterton, the old fortress or camp, is generally admitted. But the precise time when the new fortress arose is doubtful. It is not mentioned

in Domesday book, and this seems to indicate that it had no existence in the time of the Conqueror, who died some two years after that remarkable document was compiled. Several succeeding kings were great castle-builders, and it has been conjectured that Henry I. (1100) founded the new castle, though it is not mentioned till nearly the end of the reign of Stephen, who bestowed upon Randle, Earl of Chester, the new castle of Staffordshire, with other castles and demesnes; and this was the only royal castle in North Staffordshire at that time. A mistake in reading Camden's account of a visit to Newcastle has probably led to some confusion of dates in reference to the founding of the castle of the old borough. He speaks of having seen "the ruinous and shattered walls of an old castle," as though at Chesterton; but it seems pretty clear that it was the ruin of our castle he saw on the Castle mound, and not that of Chesterton.

It would be tedious on the present occasion to follow the history of the castle throughout its various changes of tenants or holders. It will be sufficient, perhaps, to notice several well-known names connected with it.

In the year 1215, King John (who by-the-bye, some years before, in 1203, fined the town for changing its market day from Sunday to Monday,) made a grant of Newcastle and its liberties to the famous Randle de Blonderville, Earl of Chester, a man of some celebrity in his day, and who built Beeston Castle in Cheshire, and Chartley Castle in this county. It does not seem, however, to have remained long in his possession, for it had reverted to the Crown in the next reign. The castle was under the government of a constable while in royal hands, and sundry of the tenants in the neighbourhood had to per-

form service of guard at stated times. The first constable was Henry de Audley, founder of the Audley family, of Helegh Castle, which he built. The tenants of Cnocton (Knutton), Fenton, Hanle (or Hanley), Longeton (Longton), Selton (Shelton), and several others had to keep guard for 40 days as part of the tenure of their vills. The holder of Normanecot (Normacot) held his vill "by the sergeanty of serving on foot with a bow and arrows within the said castle for eight days in time of war, at his own cost." All this appears from an old record of the Exchequer,—Testa de Nevill. The Constable of Newcastle, Henry de Audley, was a man of great possessions, and, it would seem, of considerable popularity, Old Fuller in writing of him says "What man of men was this Henry, that so many of both sexes should centre their bounty upon him? Was it for fear, or love, or a mixture of both?"

In the year 1235, in the reign of Henry III., that king granted a charter to Newcastle, and made it a free borough, giving it a merchants' guild, or body corporate. But at this time the town does not appear to have been very extensive, for the number of burgesses was only 28, who paid twelve pence a year to the king in quarterly payments. Whether at this time it first acquired the privilege of sending two members to parliament is uncertain, but since the year 1352, at least, it has done so.

Some twenty-eight years after the granting of the charter in question, Henry was induced, or perhaps forced, to grant the castle and borough to the renowned and powerful Simon de Montfort, Earl of Leicester (his brother-in-law), but his tenure was only short, for two years after, in 1265, he lost his life at the famous battle of Evesham.

Newcastle was then transferred to the king's younger son Edward, who was created Earl of Leicester, then Earl of Derby, and afterwards Earl of Lancaster. The possession of the manor of Newcastle does not seem to have always attended the holder of the castle. At the battle just mentioned, Lord Segrave (who held it) was one of the rebellious barons, and the manorial authority was taken from the family. It was soon after united to the castle and borough.

Newcastle passed through various members of the Lancaster family until, in the time of Edward III., it came into the possession of his third son, the famous John of Ghent (or Gaunt, as he is more commonly called)—"time-honoured Lancaster," as Sir Walter Scott designates him. This nobleman played a conspicuous part in the politics of Europe in his day, and was justly celebrated. In no respect did he distinguish himself more, at least for the benefit of his country, than when he took the part of John Wickliffe, and personally accompanied that remarkable man, "the morning star of the Reformation," when he was summoned, by order of the Pope, to appear before Courtenay, Bishop of London, on account of his protest against the religious errors of the times. John of Gaunt threw his ample shield over the intrepid reformer, so that he was protected from the fury of the monks and others to whom he was obnoxious. Gaunt was afterwards created Duke of Lancaster; and since the time of Henry IV., his son, all the possessions of the Duchy of Lancaster have been more or less connected with the Crown. It will thus appear that our borough has been identified with some of the most remarkable personages in the early history of our country.

With regard to the castle itself little is known. It would be tedious to attempt an examination of the documents which lead to the conclusion that much of the original structure was of wood, the keep, however, being of stone. Several grants of timber seem to have been made in the reign of John for repairing and fortifying his castles, and among them Newcastle. That monarch appears to have paid a visit, in passing, to this castle, and some royal mandates are dated from it. It has been supposed that the rude figure of a castle in the borough arms is not altogether imaginary, but is a fac-simile of the old structure; and if so, it would confirm the notion that it was in part of wood, the gables presenting an appearance similar to the old timbered houses which formerly prevailed, and of which some interesting specimens are still to be seen in this and several neighbouring counties. The following singular description will still further confirm the opinion. It is copied from an entry in an old book of the date of 1602 (probably written in it soon after the year 1610) when the site of the castle, and some mills contiguous, were granted by the crown to Ralph Sneyd, Esq., of Keele.

"There be many that need be tould what John of Gaunt his castle was, and will sore lament it now is not, to give the sojourner largess of bread, beef, and beer. Our grand-dames doe say that their grandames did delight to tell what it had been, and how well it was counted off before their daye; althof they say onlie of it what they had been tould; as how that the Newcastle was no more nor 150 paces from south to north, but well nigh 200 from est to west; and had two transepts and four bays with dungen tower of twentie paces square, which rose in three storys of the full height of 70 feet: that it did stand

over all the knoll in the middest of the picturesque vale and gentle rising hills, very delightful and riche in pastur and woodlandes, and to the west and north remnants of divers parkes belonginge. A low portal, and not well lighted passage, did admit to the halle, very large and spacious, with roof lofter, and painted with devices, gallerie for the minstrels, and the walls clothed with geer of warfare, helmets, coates of mail armour, buff jerkins, like shirtes, and such like doublets. Wending a gloomy staircase did lead to the state rooms and bedd-chamber of the prince, and other on the upper for companie. The drawbridge on the north did approache into the court, ninetie paces in length, with thirtie in the width, and south and west were two lesser. The walls outer had good buttresses to the height of thirty feet, and the whole was moer fytt as a stately comfortable dwellinge then as a fortress of defence, cause of the rising landes south and est. It almost now is all carryed away, and measter Sneyde doth hold the ground, and the mote, and the mills."

Newcastle had also its monastery of Black Friars. It was not, I believe, a large establishment, and little is known of it, except the site, which was at the bottom of Friars'-lane, and near Friars'-wood. In preparing the new Smithfield for the town, some of its foundations were recently laid bare. Several stones were dug up, parts of window mullions, and others bearing indications of ecclesiastical architecture. A key having the same character was also found, and may now be seen. If an opportunity could have been afforded of more extensive excavations on the spot, it is not improbable that other relics would have been discovered, and traces of the building have been brought to light. But in these utilitarian days it could hardly be expected that any relics of

"the monks of old," however interesting, could stand in the way of a cattle market.

Some persons have supposed that in days of yore Newcastle was more considerable in extent than in later years, and that it had four churches. I cannot, however, find any confirmation of this opinion. The borough records are said to make mention of "Saint Mary, beyond the water," (*i. e.* over the brook or pool); and a St. Katharine's and St. Leonard's are also spoken of; but it is most likely that these were only chantries belonging to the church of St. Giles the Abbot, itself originally a chapel under the mother church of St. Peter at Stoke. St. Giles's church was probably an interesting structure, if we may judge from the fine old massive tower of Early English which still remains, joined on to the incongruous re-erection of the last century—an enormity which was perpetrated in the year 1720. I have enquired in vain for a view of the church as it formerly stood. If any such existed it has been lost during the 150 years that have passed away since it was levelled with the ground. It would, if found, be a pleasing momento of old Newcastle.

I must not pass over an amusing article which formerly belonged the borough. Had the present meeting taken place a score of years ago, I might have exhibited (what I several times myself saw) a device of our ancestors for making a quiet woman—an iron bridle for scolds, an article for which Newcastle was famous. I hope the ladies will not misunderstand me; I do not mean that Newcastle was famous for its scolds, but for its bridle; though possibly some sharper in logic would contend for the inference, that if Newcastle had a bridle for scolds it must have had scolds for its bridle. Be it as it may,

we hope that the scolds are of the past, as the bridle itself is, at least so far as the town is concerned; for within the last few years the bridle has mysteriously disappeared, and its whereabouts is unknown. It is whispered that it is to be seen in the Museum at Liverpool; but I cannot affirm it. The following is Dr. Plot's amusing description of this feature of the old borough:—

"They have a peculiar artifice at Newcastle and Walsall for correcting of scolds, which it does too so effectually, and so very safely, that I look upon it as much to be preferred to the cucking-stool, which not only endangers the health of the party, but also gives the tongue liberty 'twixt every dip, to neither of which is this at all liable, it being such a bridle for the tongue as not only deprives them of speech, but brings shame for the transgression, and humility thereupon before it is taken off. The instrument being put upon the offender by order of the magistrate, and fastened by a padlock behind, she is led round the town by an officer to her shame, nor is it taken off till after the party begins to shew all external signs imaginable of humiliation and amendment."

Dr. Plot, who was a gossiping writer, makes mention of the Gallows-field, situated in the Higherland, where criminals were executed, for by an old charter Newcastle had the right of putting to death certain criminals taken in the act. He states, upon the authority of an alderman of the borough, that a stone was found there in which the skull of a man with the teeth in it was imbedded. At several times human bones have, I believe, been dug up on the spot. He also speaks of a certain butcher, Godfrey Witrings by name, whom he saw take up by his teeth a form 6 feet 10 inches long, and 56lbs.

in weight, by one end, and holding both his hands behind him, lifted up the other end the whole height of the room, which the doctor says, by computation according to the centre of gravity, shows that he lifted with his teeth about 160lbs. weight.

Passing from this hero of Newcastle to others of a different character, I may just mention before concluding that the town gave birth to two men of some renown in their day, and who exercised considerable influence during the civil wars in the time of Cromwell,—one a soldier, the other a divine. The former of these, General Harrison, was one of Cromwell's major-generals, a body of men said to have been appointed by Oliver to keep a look-out against all parties whose influence he was anxious to hold in check, not only Cavaliers, but also Presbyterians, Independents, and Republicans. Thomas Harrison was the son, some say of an attorney, but, I believe, more correctly, of a butcher of respectable position, and an alderman of the borough. He was born in the house now occupied by Mr. Harrison, carver and gilder, in the High-street. It is said that he deserted Oliver (but not "the cause") when he found that he aspired to absolute authority. Harrison was among the regicides who were tried after the Restoration, and was condemned as a traitor. His head was set up at Westminster, and his body quartered. He died peacefully, protesting that the cause for which he suffered was still dear to his heart.

The other individual to whom I referred was John Goodwin, whose character as a theologian ranked high among the Puritans, though he was opposed to many of them in his theology. It has been said that "he made

more noise in the world than any other person of his age, rank, or profession." A voluminous writer, he entered warmly into the fiercely-contested controversies of the times. He was educated at Queen's College, Cambridge, was Vicar of St. Stephen's, Coleman-street, but ejected from his living in 1645, and died in 1665, at the age of 72. I may mention also that John Bradshaw, who presided at the trial of Charles I., was Recorder of Newcastle, though not a native. He resided I believe, at Congleton. These notices go far to prove, what may be known from other sources, that "the old and loyal borough," as it now delights to call itself, was a strenuous supporter of the Parliamentary cause against the unfortunate Charles I.

I might have mentioned other parties connected with Newcastle, and have entered more into detail on several points, had time allowed, and were this the fitting occasion to do so. But I have said enough to show that the old borough has some claim to distinction, not only in the county of Stafford, but also in connection with the annals of our country. A borough which has been represented in Parliament since the time of Edward III., which can boast of having had some 600 mayors, which has numbered amongst its sons or connections the persons whom I have mentioned, which has not been deficient in educational resources (yet further to be developed), which has ever been ready to respond to appeals for doing good, is surely not an insignificant portion of our great country. I trust it will ever maintain a high character for usefulness and loyalty, and for its support of the best and highest interests of religion and truth.

Long may the old borough maintain her good name
For loyalty, truth, and all deeds of high fame.
May the citizens always be ready to stand

In defence of the right, the Queen, and the land.
May the justices do what is just to the town,
And the aldermen stout never sully their gown ;
And then, with the councillors, wise and at peace,
"The weal and the worship" will grow and increase.

THE TRENTHAM GRAVEL BEDS.

BY WILLIAM MOLYNEUX, F.G.S.

THE section opened up by the gravel workings in Trentham Park contains, I take it, as clearly as any section can well do, the whole of the characteristic features which distinguish the middle or conglomerate division of the New Red Sandstone of the Midland counties. Consequently, it is possessed of an interest which I trust may be found sufficiently instructive to justify its selection as the place of meeting of so many geologists and others, whose knowledge of the formation in other localities is doubtless both extensive and accurate.

Before referring particularly to the masses of rock and gravel piled up before us, I may be excused for remarking, as briefly as possible—not for the purpose of offering information, but merely to explain the geological horizon of these deposits—that, taken in the ascending order of the geological scale, the Coal Measures are succeeded by Permian rocks, and these in turn by the Lower soft mottled sandstones, and the Conglomerates or Pebble beds of the Bunter group of the New Red Sandstone, as illustrated in the deposit before us.

In North Staffordshire the Coal Measures are estimated at over 6,000 feet in thickness, the Permians at about 500 feet, and the two divisions of the New Red Sandstone at

about 500 feet. It has been considered questionable if the Lower mottled sandstones occur in this neighbourhood, but on the east or opposite side of the hill in which the quarry is situated may be seen a series of variegated soft sandstones which I think not unlikely to be members of those beds.

Now it is a point of no inconsiderable interest that almost within the distance of a stone's-throw from the place where we now stand there exist at the surface members of each of the different formations described above. Rising to the north-west are the Hanchurch hills, consisting of the yellow sandstones, shales, limestones, ironstones, and thin coal seams of the Upper Coal Measures. On the east and west, at a much lower level, occur the dull brown and chocolate sandstones and breccias of the Permian group, and upon these rests the base of the elevated and isolated ridge of Bunters which form the subject of our examination. The Hanchurch Coal Measures, which occupy higher ground than the park hill, of which the Bunter is composed, are brought in by a fault of 1,000 feet upthrow, and their position therefore tells us plainly enough that even in connection with the surrounding strata of a higher geological horizon, which of course by no means represents the actual results of the operation, at least 1,000 feet of the Permian and New Red beds by which they were at one time covered have been removed at this particular point by denudation. With regard to the fossils of these Coal Measures, I may remark that they have yielded some excellent specimens of plants, and I have collected from the limestone beds and shales Spirorbis carbonarius, some species of Cythere, and several specimens of the genus Anthracomya.

The Permians of this locality consist principally of dull brown and chocolate sandstones, with occasional intercalations of clay and marl. At the crown of the second hill west from this point a roadside cutting exposes a highly calcareous hœmatitic breccia. and overlying this occur some whitish sandstones impregnated with green carbonate of copper. A similar breccia also exists near the entrance to the Spring Valley. I may here remark that I have found in Swinnerton Park, running north and south, a narrow ridge of basaltic rock not unlike Rowley rag. About a mile to the east are situated the well-known Beech Cliff quarries of Keuper sandstones, which supplied the stone used in the erection of the old Trentham priory and church.

We now come to the consideration of the beds immediately before us. The section, as may be seen, opens up about 100 feet of coarse consolidated gravel, more or less intersected by irregular bands or deposits of soft pebbly sandstone. The colour of the beds is principally a reddish-brown, but towards the base come in a thick mass of soft, gritty, white and yellow sandstones containing comparatively few pebbles. The whole of the beds dip rapidly to the west, and one may readily find therein illustrative examples of false and current bedding, and other evidences of turbulent action. Near the top of the section is a band of dull red flaky sandstone, called by the quarrymen "the silver mine," in consequence of the surface of the laminæ being thickly coated with glistening mica. Running completely across the quarry at right angles to the dip of the beds are two fissures from two to three inches wide and filled in from above with fine clay or marl. There are, besides these, numerous smaller fractures or fissures which, however, have no uniformity of direction:

they diverge from, intersect, and unite with each other upwards and downwards, and are evidently deep-seated, being due in all probability to a fault which runs at the foot of the hill and brings in the Permian strata.

With regard to the sandstones and gravels, there is no regularity whatever in their arrangement. They come in, go out, thicken, divide, reunite, become wedged within each other, and assume other forms which, extending over even this limited area excite one's curiosity as to the actual character of the conditions under which they were deposited. If we continue our examination closer and closer, if we take up a handful of the sand, or peer amongst the loosely-piled coarse pebbles, or the finer gravel, in the wall of the quarry, we shall find that, with the exception of a little coating of siliceous or calcareous matter and here and there incrustations of oxide of manganese (which latter are, however, confined to well-defined lines), the whole mass is singularly free from extraneous or earthy substances—a condition which indicates the absence of mud-depositing rivers communicating with or flowing into the old Bunter seas.

The pebbles of which the gravel is composed are all water-worn and well rounded, and consist of fragments of a great variety of quartzose and siliceous rocks, and include (with others) agate, chalcedony, cornelian, jasper, porphyry, syenite, Silurian sandstones, old conglomerates, Carboniferous limestone and chert, Millstone grits, indurated marls, and volcanic ash; but it is remarkable that there are no examples of true granitic, hornblendic, or schistose rocks, or of rocks of less ancient age than Millstone grit. The Silurian sandstones contain an interesting series of fossils, consisting of Pentameras oblongus, P. lens,

Atrypa hemispherica, A. reticulatus var., Spirifer crispus and trapezoidalis, Strophomena depressa, S. compressa, S. pecten, Pterinea demissa, Euomphalus sculptus, Orthis elegantula, Holopea sp., Holopella absoleta, Palæocyclus præacutus, Halysites catenulatus, Petraria subduplicata, P. crenulata var., Phacops Weaveri, Tentaculites Anglicus. The Mountain Limetone series consist of Poteriocrinus crassus and other species, Rhodocrinus sp., Actinocrinus sp., Platycrinus sp., Lithostrotion irregulare, L. Martini, Michelinia megastoma, Zaphrentis sp., syringopora reticulata, Fenestella plebeia, Phillipsia sp., producta semireticulata, P. concinna, P. mesoloba (?), Steptorhyncus crenistria, Spirifer triangularis, S. bisulcatus, S. octoplicatus, S. glaber (?), Chonotes variolata, C. Hardrensis, Dentalium ingens. Of the latter series of fossils encrinital stems are by far the most numerous, and the matrix in which these are enclosed, in fact nearly the whole of the fragments of Carboniferous limestone containing fossils, whether by being subjected to great heat, or by some chemical process, are soft and white, and easy of disintegration. In a similar condition we find numerous agates, the thin blanched laminæ falling off to the touch in a remarkably interesting and suggestive manner. More interesting, however, and more remarkable still are the curious spots with which we see almost every pebble, whatever its size, if of a sufficient degree of hardness, more or less covered. In fact these spots are unmistakably characteristic of the Bunter gravels over the whole area of their occurrence. I have never noticed them in any other gravels, nor are they retained by individual pebbles which by denudation become, as they very largely do, mixed up with and enter into the composition of drift and valley gravels of more recent age. I do not know if the presence of these spots has been satisfactorily accounted for, but if we, as we may do in this particular quarry, examine thousands upon thousands

of these impressions we shall find that they are mere surface markings, and have every appearance of being due to pressure or the grinding action of one pebble against another after consolidation. But if pressure or concussion be the cause, how may we account for the forces by which they were produced? Were those forces applied from above or below? If there were any difference in the size or character of the spots—if they became smaller or weaker as we go downwards in the section—we should perhaps be led to think that the producing cause was directed from above; or if the spots became larger and more distinct at the base of the section we might be inclined to the opinion that the seat of the movement was down deep in the crust of the earth; but in reality there is no difference in the markings of pebbles from whatever point they may be taken in the quarry. They are of a uniform character, and this peculiarity holds good in every Bunter gravel bed which has come under my notice in the midland counties. I beg to recommend this peculiarity in the Bunter gravels to the careful consideration of those of our friends who have honoured this meeting, to whom the subject offers inducement for investigation.

One other point for consideration in connection with these pebble-beds, which is, although not peculiar thereto, at least worth notice. By making a careful search amongst the pebble heaps we shall be able to obtain, particularly from indurated marls, a very interesting series of beautiful dendritic markings.

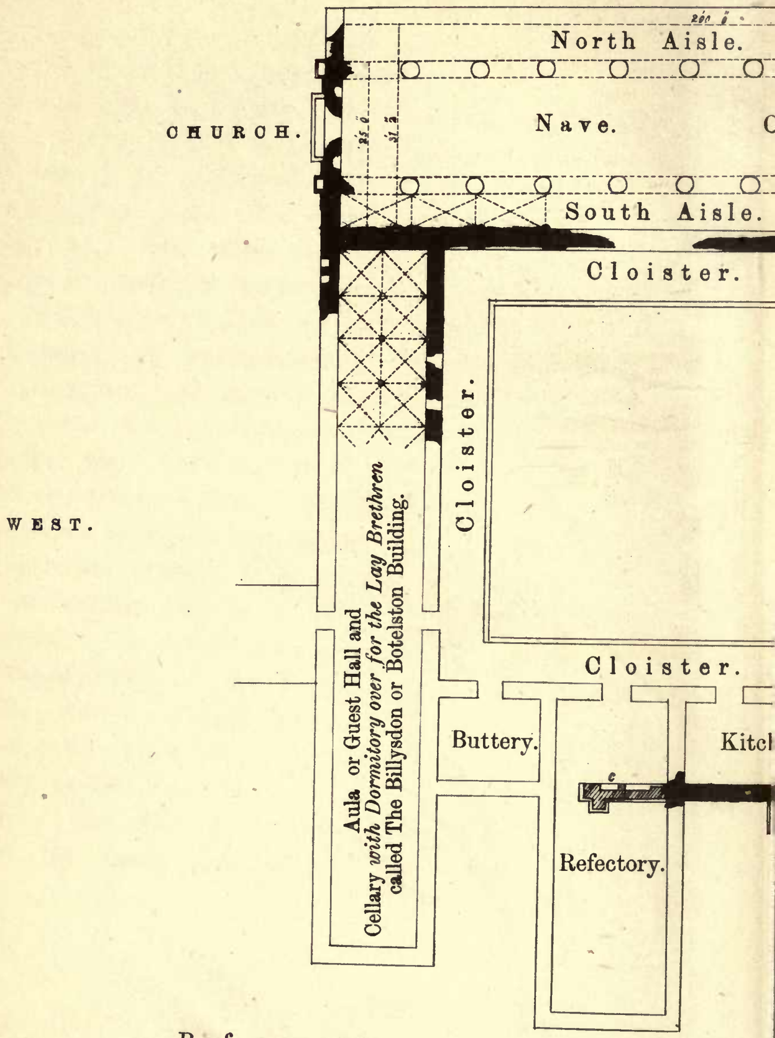
At the commencement of my paper I ventured to remark that the section before us possessed the whole of the characteristic features appertaining to the Bunter pebble-beds. In this I hope I may be permitted to think I was

correct; but while on the question of detail in connection with these deposits I would beg to draw your attention to a condition which does not occur in the section before us, and which is certainly not a characteristic feature of the gravels in any locality. I allude to the presence of copper, lead, and zinc ore, which I have recently discovered to exist in the Bunter pebble-beds of Cannock Chase. The occurence of ores of this description in Bunter gravels is in itself a matter of some little interest to both North and South Staffordshire geologists, and I have much pleasure in placing it on record on the present occasion. The copper ore, a green carbonate, is largely disseminated amongst the gravels of the Huntington pits, belonging to Lord Hatherton, on the Stafford and Cannock road, about two miles from Cannock; and beneath this, confined to two thin bands of gravel and following the natural inclination of the beds, occurs lead and zinc ore; and lead ore is now being found freely associated with a highly calcareous conglomerate in the sinkings of the Fair Oak Colliery on Cannock Chase, near Rugeley.

We now come to the general question of the origin and distribution of the Bunter gravels. They are found in each of the four kingdoms which constitute Great Britain. They come down to the sea at Belfast, they surround Liverpool, extend to Manchester, Stockport, and Chester, round by Bridgnorth and Kidderminster, and, reappearing at Milverton and Wellington in Somersetshire, pass beneath the sea at Teignmouth and Exmouth. They occupy large tracts of the counties of Stafford, Chester, and Warwick in the west, and of York, Derby, and Notts on the east of the Pennine chain, and everywhere may be found the same description of coarse gravels, sandstones, and associated fossils as those existing in the Trentham beds. Now it

is held, and with some degree of truth, that these beds gradually become thinner and occupy a less important and definite position towards the south and east. This being the case, it is reasonable to conclude that the rocks from which they were originally derived are situated to the north and west, and that by the agency of waves and currents they became scattered in broad thick masses over the floor of the Triassic sea. But where was the shore line, and what formation constituted the land surface of this remote period? If among the gravels we could but find well-defined fragments of contemporaneous organisms, either of plant or animal, the answer would be there, but the gravels are in this respect silent. Neither are we clear as to whether there were periods of tranquillity or rest during the deposition of these beds, nor even by approximation as to the geological time occupied in the collection of such enormous masses of gravel and shingle. But however our wonder may be excited by speculating on these subjects, it is equally striking when we consider that the exposed area of the Bunter gravels represents but a tithe of their original extent; and that of this hundreds of square miles have been subsequently subjected to denuding agencies by which, in following the law of redistribution, they have so largely contributed to the infilling of the great valley systems of the midland counties.

CROXDEN ABBEY—GROUND PLAN.



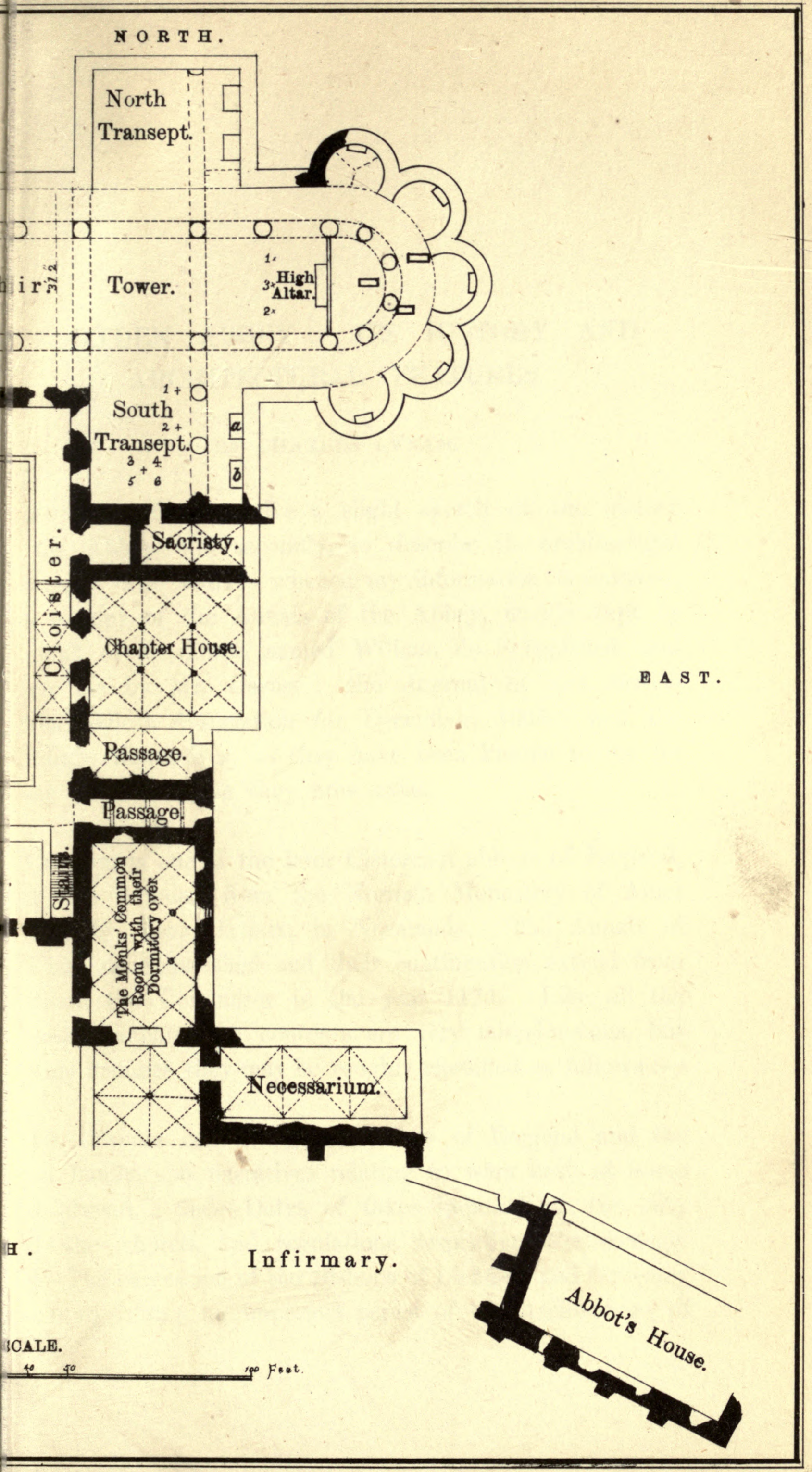
References.

a *Altar of the Holy Trinity.*

b *Altar of St. Benedict.*

c *Wall constructed in modern times out of old materials.*

Note.—The black shews the existing ancient walls.


NORTH.
North Transept.
Tower.
High Altar.
1
2
3
South Transept.
1 +
2 +
3
4
5 + 6
a
b
hir
Cloister.
Sacristy.
Chapter House.
Passage.
Passage.
Stairs.
The Monks' Common Room with their Dormitory over
Necessarium.
EAST.
H.
Infirmary.
Abbot's House.
SCALE.
40
50
100 Feet.

CROXDEN ABBEY: ITS HISTORY AND ARCHITECTURAL FEATURES.

BY CHARLES LYNAM.

I PURPOSE first to give a slight sketch of the history of the Abbey, and secondly, to describe its architectural features. The sources whence my information is received, are, a copy of the Annals of the Abbey, mostly kept by a monk of the house named William de Schepished, and given me by Mr. Garner; the Journal of the British Archæological Association for December, 1865; and the buildings themselves, as they have been known to me for many years past, as they now exist.

Croxden is one of the later Cistercian abbeys of England, and was founded from the Norman Monastery of Alnet or Aulney, near Bayeux, in Normandy. The Annals of William de Schepished and their continuation extend from William the Conqueror to the year 1174. Like all the monastic annals, the contents are very miscellaneous, but in this instance they may be roughly classified as follows:—

1st—Events concerning the Kings of England and the royal family, and narratives relating to wars both at home and abroad. 2nd—Dates of taxes imposed on the laity and the church, and regulations respecting the coinage. 3rd—The succession of the Bishops of Lichfield and Coventry down to 1322; an imperfect series of the Archbishops of

Canterbury down to 1333 ; and occasional mention of other bishops, &c. 4th—The foundation of several Cistercian monasteries. The erection and destruction of various churches, &c. 5th—Records of eclipses, earthquakes, comets and stars, storms, years of famine and plenty, and seasons of drought and of wet. 6th—A complete series of notices of abbots of Croxden for the first 200 years of the existence of the Abbey, in which the date of the erection of its buildings is accurately defined, and a genealogy of the family of de Verdun, the founders of the Monastery, is given. 7th—Some account of the author of the Chronicle and of some members of his family.

William de Schepished took his first vow in A.D. 1288, and was ordained priest of Walsall, by the Bishop of St. Asaph, on the 26th February, 1294, so the annals after this date could not have been compiled by this monk. Some of his relatives were monks, and some of them in his own Abbey.

We learn from the Chronicle that in 1176 Bertram de Verdun, from pious motives, gave to the monks of Alnet, or Aulney, the land of Chotes to found an abbey to Saint Mary, but, says the Chronicle, it was ordained they should praise the name of the Lord in another place. Chotes is supposed to be the place now called Cawton or Cotton, not far from Croxden. In 1178 the first monks of the monastery must have been brought together. They were all from abroad, but one Thomas, an Englishman, was elected first abbot. In the next year the removal from Chotes to Croxden took place, and in 1181 the *place* of the Abbey was dedicated. Thomas, the first abbot, elected on the day of Pentecost, 1178, being yet a deacon, presided over the house for fifty-one and a-half years, and although

"busied with the erection of very many buildings," wrote out with his own hand the beautiful volumes containing the greater part of the Bible. He died, or as the old chronicler expresses it, "he rested in the Lord," on the 4th of December, 1229, and was buried in the chapter house. The buildings upon which he was engaged seem to have formed the foundations of the church and of some parts of the domestic buildings, but his interment in the chapter house, and that of Nicholas de Verdun before the high altar, seem to indicate that the plan, at least, of the buildings was arranged and carried out.

In 1230 Walter de Chacumb was elected abbot. He ruled but a short time, and was buried in the chapter house on the south side of his predecessor.

In 1234 William de Esseburn was elected abbot on the octave of John the Baptist, but he died in the autumn of 1237, on his return from Citreaux, and was buried "in foreign parts," and to him succeeded John de Tillon, but he "laid down his office in 1242."

In this year Walter London, prior of Stratford (in Essex,) was elected abbot, and on the Sunday before Ascension undertook the government of the house, at whose entrance upon office the monks believed that the Lord had bestowed a special blessing upon their place. He wonderfully augmented the convent, and made the buildings very beautiful in the gates of the monastery, the half of the church and chapter house, and of the refectory. He built the kitchen, the dormitory, the chamber of the sick, with its cloister, and the sheepcote, and he erected many other buildings with great skill, and furnished them in a laudable manner. Lastly, towards the close of his life he erected a stone

wall round half of the Abbey. At his death it is said he had completed the Abbey to the utmost. The dedication of the church took place under his rule in 1253. He departed this life on the 28th June, 1268, "leaving the memory of himself in blessedness to posterity."

The Abbey was then vacant for four months and three days, but on St. Peter's day, 1268, William de Howton succeeded to the chair, who built the upper and lower abbot's chambers in an admirable manner, giving for the work £100 sterling. He also bought a Bible in nine volumes, with excellent notes, for fifty marks sterling, glossed by Master Solomon, archdeacon of Leicester. He died abroad on the 16th September, 1274, probably attending a chapter of the order, and was interred at the parent abbey of the Cistercians, Citreaux, more than 400 abbots attending his obsequies. On the 20th October in this year died John de Verdun, "a mighty patron of this house," and was buried before the high altar of the church.

On the 13th December, 1274, Henry de Moysham succeeded to the abbacy. He finished the wall round the Abbey. He released himself from the burden of the pastoral care, and retired from his charge by reason of weakness, on the day of St. Barnabas the Apostle, 1284, and died in 1286.

John de Billysdon, "a man exceeding all in gentleness," succeeded on the same day that his predecessor resigned. "This man could in truth and reality be called by the name of John:" he was greatly beloved in the eyes of all who beheld him. "He abounded also in richness of corn, wine, and oil." So plentiful was the harvest in 1288, that carts could not be found to carry the hay and corn.

To him may be attributed the cellary or west wing of the monastery, called in later times the Billysdon building (corrupted into Botelston). He "departed to Christ" on the 8th July, 1293, and was buried in the chapter house on the north side of Thomas the first abbot. The Abbey was then vacant for nearly a year.

On Holy Trinity day (1st June, 1294,) Richard de Twyford, "a man excelling in all religion and devotion," was elected father of this monastery. He, after three years' faithful ministration, paid the debt of human life, also on Trinity day, 1297, after special devotion from his first profession at the altar of the Holy Trinity. He was buried in the chapter house, "beyond the pulpit," next to Walter de Chacumb. The ordination to the priesthood of the author of the chronicle was in his time, and in the night after his burial it is recorded "that the church of Lek (Leek) was burnt down, together with the whole town, by accident." A vacancy of more than seven months followed.

William de Over was elected abbot on the 30th December, 1297. In 1300 the underkeeper emptied a large pool and found but little fish, with the exception of 500 eels or thereabouts. In 1301, on the day of the Blessed Mary Magdalene, about the sixth hour, a great earthquake took place, to such an extent that all the persons in the convent, being at their first refection, were dismayed with a sudden and unlooked-for trembling. In 1302, the bell of collocation was first hung in the church. The Chronicle records, in 1303, "our wood of Lyewode was burned at our grange of Chedle." In 1308 the abbot of the house being cited to the general chapter, and not going, was deposed from his office by the said chapter. He augmented the library

with many books, and "purchased our house at London for £20 off Fulco de Saint Edmund." In this year he died, and was buried in the cloister of the monks, without the church door, near the scamnum or exchange, the place where traders were admitted to sell wares to the monks.

Richard de Esseby, who had been prior since 1298, was elected to the abbacy in 1308, on the day of St. Gregory the Pope. In the year 1399, T. de Verdun, the patron, died on the feast of St. Bartholemew the Apostle, at Alveton, and was laid by the side of his fathers in this church with great honour, concerning whom it was said, "He died, and was as tho' he died not, for he left behind him one like to himself both in name and reality." In 1312, Matilda de Verdun, Lady Alveton, gave birth to her fourth daughter, Margaret. Lady Matilda dying within a month of her birth was buried with great pomp in the Abbey church, near the altar of St. Benedict, Gilbert, bishop of Armadown, being the officiating minister, the Earl of Lancaster, with all the nobility of the county, attending the funeral. On the 23rd of May, 1313, Richard de Esseby laid down his office, and Thomas de Castreton, prior of the house, was canonically elected. At the same time, in the presence of the visitors and the whole convent in full assembly, the usual seal of the abbot of the house was broken, and it was enacted that a common seal should be made according to a royal statute, and that it should be placed in the charge of four of the most worthy monks of the house, and it was made accordingly. On the vigil of Easter the great bell of the house was unfortunately broken, and Master Henry Michel de Lichfield came to cast another, and laboured at it with his youths from the octave of the Trinity to the feast of the Nativity of the Blessed Virgin; and then failed in casting it, losing all

his labour, but, beginning it afresh, he completed it, at last, about the feast of All Saints. In 1319, Alveton Castle and the patronage of the Abbey passed to the Furnivals, Lords of Worksop and Sheffield. At this time a plague or murrain visited the cattle through the whole land, and this house sustained thereby a loss in cattle of 200 marks. The new Lord of Alveton, Thomas de Furnival, made many exactions upon this house, to wit, certain daily distributions of alms at the gate, the keeping of his horses and hounds in any numbers he pleased to fix, the maintenance at table of seven of his bailiffs from Alveton, every sixth day throughout the year, in a room specially set apart for their use. Thus and otherwise he caused great trouble to the monks, until at length, under a writ, terms were made by agreement as to these matters between the Lord of Alveton and this house. In 1320, on the 11th of June, Richard de Esseby was again elected, nothing being said of the death of Thomas de Castreton. From infirmity, Richard de Esseby resigned his office a second time on the 23rd May, 1329. He died in November, 1333, in the 52nd year of his profession and the 70th year of his age, and was interred before the altar of St. Benedict, in the south transept of the church.

On the second resignation of Richard de Esseby in 1329, Richard de Schepished was called to the charge on the 12th of June. In the following year it is said an eclipse took place of the sun, in the afternoon of the 16th of August. Before this, for two months and more, and afterwards for three months, so great a fall of rain burst forth, and so unusual and unseasonable was the state of the atmosphere, that the crops could not ripen; consequently in several places of the country they did not begin to reap until Michaelmas; so that at Croxden they had scarcely

completed reaping by the first of November, and at length they stowed away their peas in granaries, &c. Strange to say, early in November, and up to Martinmas, peas fresh in pod were given to the convent in the refectory instead of pears and apples. On the 24th December a very violent wind blew from the west, and unroofed the buildings of the Abbey and of the whole country to a terrible extent, and entirely threw down from the foundations several of them, and tore up in a wonderful manner from the roots innumerable oaks in the woods, and apple trees and pear trees in the gardens. More woods were also burned this year.

In 1332, the whole cloister of the monks was roofed anew all round, and according to the account of the carpenters, shingles were used to the value of twenty-five marks five shillings and sixpence. In 1333, the refectory and central tower were roofed anew with shingles which cost more than nineteen marks. Such was the salubrity of the air this year, that the harvest was very early and sowing for the next crop also. In 1334, the dormitory of the monks with the buildings adjacent to it, to wit, store rooms and necessary offices, and also the dormitory of the abbot, were roofed anew, in a fit and becoming manner, with new shingles, nearly thirty marks' worth, and all the spouting and gutters, which were before of wood, were made of lead. In this year Lady Joanna de Furnival of Alveton, the last of the Verduns, died in childbirth at the premature age of thirty. The abbot of the Abbey, assisted by those from Burton, Dieulacre, and Hulton, with other venerable fathers, officiated at the funeral. Her grave lay before the high altar. In this place it is also recorded that Lord Bertram de Verdun, the illustrious founder of this house, died in the Holy Land, where he was travelling with

Richard King of England, and notice is made of all their interments.

In 1335 this abbot began to build his new chamber, between the kitchen of the infirmary and the dormitory, and in the following year he completed it at great expense. In 1336 an abbey pool was made in Lent. The King exacted wool, at a certain number of sacks and for a certain price, the number for Staffordshire being 600, and the price nine marks, but he paid nothing at all. The winter was very severe and long, and the snow very deep. In 1339, Margaret the daughter of Thomas de Furnival (and at whose birth the last of the Verduns died,) also died, in the 19th year of her age, at Sheffield, an office on her behalf being celebrated at Croxden. In the same year Thomas de Furnival also died at Sheffield, and was buried at the monastery of Beauchief, by the abbot of Croxden. Whether this was Richard de Schepished is not said, nor is his name mentioned again nor the date of his death. In his time Roger, Bishop of Coventry, held a visitation at Alveton church, and slept the next night at Croxden Abbey, where he examined the muniments of the convent relating to their possession of that church.

The years 1340 to 1344 stand blank in the Chronicle. In 1345 the wood of Gibberiding and others were sold, and houses at Shaw, Combrigge, &c., built without sparing labour or expense. In this year it is said sheep and other animals perished from rot, famine, and cold. In 1346, the pool last referred to gave way and was repaired. The year 1347 is blank, and 1348 nearly so. In 1349 it is said, "there was a great pestilence throughout the whole world." In 1350, "This year was a jubilee." From 1351 to 1361 nothing is recorded except in the latter

year this is said, "A second pestilence took place, and all the children that were born since the first pestilence died." In 1367, Alexander de Colbeley, who succeeded Richard de Schepished, and of whom nothing else is related, was deposed: on the day thereof, 13th January, 1367, William de Gunston was elected abbot by the whole convent. The abbot of Alnet sent a commissary to visit Croxden at this time, its affairs being in confusion, the debts amounting to 152 marks eight shillings and elevenpence.

In 1368 there was a great scarcity of grain: one bushel of wheat was worth in London two shillings and more, one of barley twenty-pence, and two bushels of oats twenty-pence. In 1369, was a third pestilence. In the same year they began to sell the wood of Grete, and the sale lasted for three years. Also the house called Botelston fell down from the church, as far as the door of the aula or hall, except three couples, and in the next year it was rebuilt in large timber, and covered with nineteen and a-half marks' worth of shingles. In 1372 the ditches were made at a total cost of seven marks. In the same year a heavy flood destroyed all the grass growing near the water, and all the bridges across the Churnet were totally destroyed. Also in the same year a tempest in the daytime took the lead off the dormitory, infirmary, and abbot's chamber, and threw down half the trees in the orchard, and thirty oaks at Grete, and the large granary of Musden. This last was rebuilt the next year. In 1374 the last recorded work at the Abbey was done, namely, three corners of the cloisters were repaired, and both the north and west walls near the church were roofed in anew, and also the church with "clamp irons." Thus ends the Chronicle of William de Schepished, monk of the Abbey of Croxden—

"To be, to have been, to be about to be are three vain periods of existence. For everything perishes which has been, which is, or which shall be. That which has been, which is, and which shall be perishes in the space of a short hour: therefore of little profit it is to be, to have been, to be about to be."

This monk's labours were carried on by another hand whose list gives the following names, after that of William de Gunston:—Philip Ludlow, Roger Preston, John de Brownefield, William Burton, Ralph Layland, John Walton, and John Shipton, at first abbot of Hulton, elected at Croxden in 1519. Thomas Chawner was the last abbot, whose government terminated in 1539, when this house was suppressed and became tenantless.

To turn from the Chronicle to the remains of the buildings. I produce a plan enlarged from one published in the Archæological Journal for 1863, on which is shown in black the parts now remaining, and also the complete form of the buildings as made out by my friend Mr. Gordon Hills, of London. They follow the Cistercian arrangement, but present several peculiarities; the most striking is the extreme simplicity of the windows, and of much of the detail: the more elaborate parts have much of a foreign aspect, due no doubt to the connection and dependence of this Abbey on that of Alnet.

The architecture of the remains is with little exception of the 13th century, and there can be no doubt that in what still exists of the church we see the work which was consecrated under Walter de London in 1241; and in the sacristy, chapter house, and two passages south of it, in the common room of the monks which forms the substructure

of their dormitory, in the "necessary offices" attached, and in the kitchen and fragment of the refectory we are looking upon the other buildings erected by the same man between 1242 and 1268. The abbot's house as we see it may with equal certainty be allowed to be that erected by William de Howton, between 1268 and 1274. The work added to the south end of the monks' dormitory is probably that "new chamber of the abbot lying between the kitchen of the infirmary and the dormitory," which Abbot Richard de Schepished erected in 1335 and 1336. Identical in workmanship with this is the vaulting of the cellary, adjoining the west end of the church, called the Billysdon buildings, spoken of in 1368 and 1369. A small portion of the Abbey gateway may yet be seen, and the Abbey mill is full of materials taken from the Abbey.

Of the ruins, the church first commands attention. The west end, with its richly-moulded doorway and stately triple lancet windows and lofty buttresses, is simple and dignified. The remains of the half columns, on the inside of this wall, denote the sort of pillars which separated nave and aisles. The remains of the south wall show that the aisles had groined vaults. A large portion of the south transept also still remains, against the south gable of which abuts the dormitory roof, and in which is the door to the sacristy, and to the monks' dormitory, being their entrance to the church for night services. On the east side of the transept were two chapels which, with the transept itself, were vaulted. The interments in this transept were, 1—Norman de Verdun, father of the founder. 2—Theobald de Verdun, died 1399. 3—Matilda, died 1312. 4—Theobald, son of Theobald de Verdun, and husband of Matilda, who died in 1316. 5—The infant son of these, named also Theobald. 6—Abbot Richard de Esseby, who died

in 1333. The two chapels to this transept were dedicated, one to the Holy Trinity to the north, and the other to St. Benedict.

The fragment at the east end is just one half of a small apse, which was evidently attached to the circular end of the church. This little chapel had a vaulted roof, and was lighted by a single lancet window, and is of the same date as the rest of the church. This fragment is a key to the form of the whole east end, and it shows that there must have been five small apsidal chapels round the main apse, as shown on the plan. This is an unusual eastern termination for a Cistercian church in England: it is believed the only other instance of it is at Beaulieu Abbey in Hampshire, but this was the usual form of this portion in France, and both Beaulieu and Croxden were dependent upon and had their origin in that country. The plan of Croxden is a copy of that of Alnet, which was dedicated in 1190. There the five apsidal chapels were dedicated as follows: the central one to the Blessed Virgin Mary; the others to St. Thomas of Canterbury, St. Mary Magdalene, St. John the Baptist, and St. Martin.

The great altar stood, as shown upon the plan, within the main apse. The interments before it were, 1—Nicholas de Verdun, son of the founder. 2—John de Verdun, who died 1274. 3—Joanna de Furnival, who died in 1334, and was buried between the two. Some years ago three stone coffins were to be seen in the position shown upon the plan, such situation being usually devoted to the remains of highly-venerated saints.

To the south of the south transept are the buildings of the Abbot Walter de London. Adjoining the transept is

the sacristy. West of this is a small chamber which the notice of the interment of Abbot William de Over shows to have been the scamnum or exchange. The church door before which he was buried, as we see, still remains a rich piece of work.

Next, south, is the chapter house, with its front of three arches, forming an open screen without glazing or doors. The central arch formed the entrance, and the side arches were enriched with tracery. The chapter house had a vaulted roof, as indicated by its remains. In this apartment, where the convent daily assembled, under the presidency of the abbot, were probably interred most of the abbots. Those already named in the Chronicle as lying here are, Thomas de Woodstock, first abbot; Walter de Chacumb, the second, to the south of the first; John de Billysdon, the eighth, to the north of the first; and Richard de Twyford, the ninth abbot. South of the chapter house is a passage which led from the cloister to the gardens of the monastery, mentioned more than once in the Chronicle. Next to this is another and narrower passage, which also led to the gardens, and by a door in its south wall to a common room of the monks. The walls of this room remain, but the three central columns which supported the vault are gone. The lancet windows on the east show how this room was lighted: there were two lancet windows at the south end and a door near them in the west wall. To the east of this room is the building mentioned in the Chronicle in 1334, as adjoining the dormitory. This, no doubt, was of two storeys in height. The dormitory (built by Walter de London,) extended over the common room passage, chapter house, and sacristy, except that against the church was probably the treasury. The south end of the dormitory was set apart from the first to the noviciate.

The steps leading to it are against the west wall of the common room.

Of the buildings on the south of the cloister but little remains. To the east is the dormitory staircase, a door into the south garden, and an oven indicating the position of the kitchen. Next the kitchen, westwards, just enough remains to mark the position of the refectory, in its usual place in a Cistercian abbey, built by Walter de London, and mentioned in 1333. It was in this apartment that in 1301 the monks were dismayed by the shock of an earthquake, as related in the Chronicle.

The remains of the west wing are very slight, but are enough to show that its ground storey had a row of two columns down the middle. This work shows the northern portion against the church to have been early, and the southern of later date. This wing was no doubt occupied by the cellary and lay brethren. The way from their dormitory to the church for night services is still indicated, and here probably was the hall or guest house, and this is the portion which fell in 1368, and was afterwards rebuilt, and known as the Botelsdon building. The cloister of the monks was within the quadrangle now described, and was no doubt the work of Walter de London. In front of the chapter house it had a vaulted ceiling, but wood elsewhere, as the remaining walls indicate.

Of the abbot's house built by William de Howton, between 1268 and 1274, the fragments are scanty and ruinous. In 1335 and 1336, Richard de Schepished built his new chamber between the kitchen of the infirmary and the dormitory. It blocked up the end windows of the common room. The infirmary, where dwelt the aged and

infirm of the house, was about in the place indicated on the plan. Nothing now remains of this.

We have now traced the monks and their doings through many years, but before we leave them allow me one reflection. These men builded a house of God, and this without bazaar or tea meetings. They cultivated their land in quiet industry, grateful to their founder, patrons, and benefactors, and above all, were ever mindful of Him who blessed their toil and prayers (as this Chronicle of the aged monk clearly indicates), and yet their house was destroyed, their lands confiscated, and their church desecrated, and now a common highway passes through the temple they reared for the worship of God, and beasts tread the site of their very altars. No doubt by Act of Parliament! Yet whilst all this may be right in law, and our faith, as it may seem to us, purer than theirs, let us ever remember them as *doers* in what they believed, and, of our charity, so far, think well of them.

THE LITERATURE OF BOTANY.

BY W. S. BROUGH.

Doubtless many persons are disinclined to the study of botany from an idea that it consists solely in the learning and committing to memory of a number of very hard names, and so they know nothing of the delightful pleasure an acquaintance with some of earth's brightest treasures brings. It has been truly said that the most lasting pleasures are the simplest and nearest the reach of all. With what joy does a botanist recall his hunts after varieties! The ramble in the meadows, the exhilarating tramp over the breezy moorland, the quiet saunter in the shady woods, the pleasure of the recognition of familiar friends (the common species), and beyond all, the intense delight of a discovered rarity, cannot be described by words of mine. We have so many books now-a-days, all placing the study in a very attractive aspect, and each showing the easiest way to a mastery of system, that no one need be at all alarmed by the dryness of details, but each may gain so much interest in its acquirement that the hard words themselves almost become a pleasure. But there is another side—an attractive one, and one perhaps too little considered—the human interest and literature of botany. It lies in the lives of the remarkable men who not only originally found, collected, and catalogued the plants, but also devoted their days to the drawing, and describing, and publishing to the learned world the plants

they had searched for and secured. The names of these early botanists are scarcely known to the world of general readers. I propose to introduce a few. I do not wish this paper to be looked upon as an exhaustive description of the early botanists and their labours, but rather as a few notes, the result of a slight acquaintance with some of the earlier English Herbals and Histories of Plants (copies of which I am glad to be able to show you), a brief glance at the strides made in later years towards reducing botany to a complete science, and a mention of the more noticeable works of modern times.

I may first mention (omitting all notice of the botanists of ancient times, Kings Solomon and Cyrus, Discorides, Theophrastus, Camerarius, &c.,) the name of William Turner, the father of British botany, and the author of a New Herbal, printed in London, 1551. His biography is full of interest. He became Latimer's disciple. An enthusiast in the principles of the Reformation, he travelled about England preaching, was imprisoned, subsequently released, and obliged to leave the country. He did not return until after the death of Henry VIII. The new king favoured him highly, and made him a Prebend of York and a Canon of Windsor. The incidents in his history are quite romantic, and there is a short account of his life in the "Sketch of the Progress of Botanical Investigation in Middlesex," in "The Flora of Middlesex"—a work of great merit and research, by Henry Trimen and William Dyer, very favourably reviewed in the "Athenæum" a few years ago, and to which review I am much indebted for my statements concerning these worthy botanists. It says "Turner was in his way a truly great man of whom the world is nearly altogether ignorant. He died in 1614, and was buried in the south aisle of St. Olave's church, Crutched Friars.

A stone, erected by his widow, is let into the corner of the east wall, and bears an inscription easily legible." His Herbal is very rare. He published it in three several parts, and republished these early in 1588, collected in one volume, which he dedicated to Queen Elizabeth, who had always stood his powerful friend even when he was suspended for nonconformity in 1564. The copy I have is, I am sorry to say, not quite perfect, but it is the best I have met with. The imprint reads thus—"Imprynted at London, by Stephen Wyrdman, and to be Sold in Paule's Churchyard, at the sign of the Spread Eagle, by John Gybken, 1557." The book is in black letter, and the initial letters and printer's marks are fine.

A very worthy successor of Turner was John Gerarde, well known by his famous "Herbal, or General Historie of Plants, gathered by John Gerarde, Master in Chirurgerie," and printed in London in 1597. This book will certainly take the first place in the early literature of botany: it is so quaint, so full of descriptive power, and is written in such fine English that it is really delightful to read, not only to the botanist but to the antiquarian and bibliophile, and will long hold high rank among the treasures of early English books. The best edition is the one published in 1636, "enlarged and amended by Thomas Johnson, Citizen and Apothecarie of London," of whom more anon: this edition is profusely illustrated, and is dedicated to Sir William Cecil, the great Lord Burleigh. It is divided into three books:—1, Grasses, weeds, flags, bulbous-rooted plants, &c. 2, Herbs, meat, medicine, or sweet-smelling. 3, Trees, shrubs, fruit-bearing, heath mosses, &c.

I must ask your indulgence in calling your attention to

a very curious notice of the barnacle or goose-bearing tree. "There are found in the north part of Scotland and the islands adjacent, called Orchades, certain trees whereon do grow certain shells of a white colour tending to russet, wherein are contained little moving creatures, which shells in time of maturity doe open, and out of them grow those little moving things, falling into the water, doe become fowles which we call barnacles; in the north of England, brant geese; in Lancashire, tree geese; but the other part do fall upon the land, perish, and come to nothing. Thus much by the writings of others, and also from the mouths of people of those parts, which may well accord with truth." And then follows a description of a similar wonder found on the coast of Lancashire, to which I invite your attention. This grand book thus ends :—"And thus having through God's assistance discoursed somewhat at large of grasses, herbs, shrubs, trees, and mosses, and certain excrescences of the earth, with other things more, incident to the historie thereof, we conclude and end our present volume with this wonder of England. For the which God's name be ever honoured and praised."

Passing over the labour of Lobel, a Fleming, 1570, who improved the ancient modes of distinction by taking into account characteristics of a more definite nature than those which had hitherto been employed by his predecessors, and Cœsalpinus, an Italian, who contributed to botanical arrangement in some degree, I notice Thomas Johnson, who was another worthy successor of father Turner, and the first man who printed an account of a botanical excursion in England. This appeared in 1629, when he was a flourishing apothecary on Snow Hill. He actually made up a botanizing party for an excursion to Hampstead Heath, on August the 1st, 1629, and has left a three-page record of the

particulars of that memorable day. He narrates who the excursionists were, how they walked to a country place known as Kentish Town, and had notes enough for three lists of plants, being seventy-two. In 1633, as before mentioned, Johnson published his great achievement, a new edition of Gerarde's "Herbal," thirty-six years after the appearance of the original edition. Johnson was as good a soldier as he was a botanist, and distinguished himself greatly in the Civil Wars, becoming Lieut.-Colonel to Sir Marmaduke Rawdon. Unluckily for botany, at the siege of Basing House he received a shot in the shoulder, whereby contracting a fever he died a fortnight after. Truly, as his biographer observes, "it would have been well if he had stuck to plant-collecting and shunned fighting." He was much regretted, being, as it is declared, "no less eminent in the garrison for his conduct as a soldier than famous through the kingdom for his excellency as an herbalist and physician."

John Parkinson, "the King's Herbalist," was a contemporary of Johnson, and an older man than the latter. He also was an apothecary, and had a garden at Long Acre. His book is of much note and is now rare. It is copiously illustrated, dedicated to King Charles, and entitled "Theatrum Botanicum, the Theatre of Plants, by John Parkinson, Apothecary, of London, and King's Herbalist." It is divided into seventeen parts or tribes. I may not here go into detail, but it is a very interesting book.

Dr. Merritt, who was born in 1614, and was one of the earliest members of the Royal Society, founded in 1663, was an industrious botanist.

Dr. Leonard Plukenel, Queen's Botanist, is recorded to

have been "an accomplished man for his day, and a wise man for any day, since he waited until he was nearly fifty before he published the first two parts of the 'Phytographia.' He was of the order of men who did not print before they had something worthy of being printed." He was extraordinary in his application and devotion to his favourite study. He published his work at first at his own expense, and when he had spent all his money was helped with a subscription of fifty-five guineas by a few worthy and wealthy men of his time.

Samuel Doody was another plant-lover of nearly the same period, and won great reputation as a cryptogamic botanist. The preacher who delivered a funeral sermon for Doody said "he was in botany very particular, very singular: none before him ever knew so much, and every botanist cannot be a Doody." "Yet," continues his panegyrist, "he was very slow of speech, and at first sight you would take him to be of as little sense as eloquence: he generally wanted words to express his wisdom, but when he did or could exert himself his discourse was always full of argument and sound reason, plain and improving. His notions of God and religion were sublime. The plainness and simplicity of his soul were very conspicuous."

I have now to notice a remarkable book published in 1613 — Culpeper's "Herbal." The author was a very worthy man, and during his lifetime was much resorted to for his advice, which he gave to the poor gratis. He lived and died at his house, the Red Lion, at Spitalfields, and as this would then be out in the open country, we may conclude that many of his herbs and simples were culled near there. The book will always remain a lasting monument to his skill and industry, though we cannot

now but smile at the amount of astrological superstitions with which it is laden, and given in good faith. It has passed through many editions, has had, and still continues to have, a large circulation among the humbler classes of society, and in country districts an acquaintance with Culpeper is deemed necessary to a knowledge of the nature and properties of plants.

I now come to an important book, "The Anatomy of Plants," by Nehemiah Grew, Fellow of the Royal Society of Physicians, 1682. It is dedicated to King Charles II. There is really some system in this book. The true nature of the sexual organs in plants is here demonstrated, the important difference between seeds with one and those with two cotyledons being here first pointed out. Clear and distinct ideas of the causes of vegetable phenomena are developed, and a foundation laid on which the best theories of vegetation have been established by subsequent botanists.

A few years later the French botanist Tournefort, then Professor of Botany at the Jardin des Plantes, published his "Elements of Botany," being the first attempt to define the exact limits of genera in vegetables. He at the same time announced a system for the classification of plants, and contributed very largely to the advancement of the science.

About this time, while Tournefort was engaged in arranging his system of plants, and Grew had completed his, John Ray appeared, and in his "Historia Plantarum," 1686, the real foundation of all the modern views are found. While he thus enumerated the true principles of classification he laid the foundations of the inductive system which has since distinguished the English school of botany.

Of his definition of a natural system as one "which neither brings together dissimilar species nor separates those which are nearly allied," Lindley says, "However much the words of this definition may have been varied, it still retains the very meaning given to it by its author."

The French botanists claim for Bernard de Jussieu the glory of working out the true natural system, though it was first established in principle by Ray. The nephew of De Jussieu, Laurent de Jussieu, in 1789, published his celebrated "Genera Plantarum," which raised the science and marked a new era in vegetable classification. Thirty thousand plants were known at this time, while our present list comprises over eighty-two thousand.

In 1751, forty years after the publication of Tournefort's system, and while Ray was yet pursuing his investigations, the Linnæan system appeared. This new mode of distributing vegetables was hailed with admiration. Its author, Charles von Linnæus, reigned supreme without a rival until the end of the eighteenth century, and even in our day his patrons are neither few nor powerless. Linnæus endeavoured to work out a natural system, a slight sketch of which appeared, explaining the principles upon which it might be expected to rest, and pronounced the investigations of the natural affinities to be the great object of his studies and the most important part of the science. He considered the artificial system as a temporary expedient which however necessary at that day must inevitably give place to the system of nature so soon as the fundamental principles should be discovered. "The elucidation of the latter," he said, "is the first and ultimate aim of botanists: to this end the labours of the greatest botanists should be diligently directed. For a long time," he adds, "I

have laboured to establish it. I have made many discoveries, but have not been able to perfect it, yet while I live I shall continue to labour for its completion. In the meantime I have published what I have been able to discover, and whosoever shall resolve the few plants which still remain shall be my Magnus Apollo."

In 1790, the great poet Goethe published a pamphlet on the "Metamorphosis of Plants," and we are chiefly indebted to Robert Brown for the elucidation of Goethe's theory, a theory that owes its foundation to Theophrastus, "that certain forms of leaves are modifications whose appearance was very different, demonstrating that the organs to which so many different names are applied, namely, the bracts, calyx, corolla, stamens, and pistil, are all modifications of the leaf." Auguste Pyramus de Candolle is one of the botanists of this century who have most contributed to the general adoption of the natural families. It is Dr. Candolle's system that is now most generally followed, and upon this the principal examinations are based.

But the man of all others to whom modern science is most indebted for perfecting the botanical arrangement of plants is the late Dr. Lindley. After several previous attempts, his "Vegetable Kingdom" was published in 1845, and this work remains a treasury of immense learning, technical knowledge, and vast industry. There have been many works on botany published during the last few years. One I mention: though not perhaps valuable for original research and learning, still it is so as a concise compendium of the science—"The Vegetable World," by Louis Figuier. Not the least attractive portion of the work are the numerous illustrations, engraved with exquisite skill by French engravers, the great masters in this art.

Here I would introduce, briefly, a few works by eminent botanists that might have been named in their proper chronological order, but as they do not hold a striking place in the history of the advancement of botanical knowledge I will call attention to them together as they are noticeable and quaint, and shall content myself with their names, and point out the examples which you are invited to look at afterwards.

"A New Herbal, or Historie of Plants," by Dodoens, a Dutchman, "wherein is contained the whole discourse and perfect description of all sorts of herbs and plants, their divers and sundrie kinds, their strange figures, fashions and shapes, operations and virtues, and that not only of those which are growing in this country of England, but all others else of foreign realms, commonly used in physicke. First set forth in Dutch, and now translated out of French into English, by Henry Lyte, at London, 1578." The system seems to be simply to divide the book into parts—Medicinal, sweet-smelling, and pleasant plants. Noisome weeds. Corn in grain. Herbs used in meat. Trees and shrubs.

"Sylva Sylvarum," by Lord Bacon, or, "A Natural History in ten centuries," 1627, folio, first edition.

"The Natural Historie of the World," by Pliny, and translated by Dr. Philemon Holland, 1634. A very curious work and now very rare.

"Flora," by John Rea, 1665. More especially a horticulturists' book, but notable.

"The Complete Gardener," by M. de la Quentin, trans-

lated by John Evelyn, 1693. Introduced because of the portion devoted to vegetable physiology.

"Silva and Terra." A well-known work by the renowned John Evelyn, of Wotton. Edited by Dr. Hunter, first edition, 1664. In the copy here (of course a later edition) there is a portrait of the author, by Bartolozzi, very fine.

Plot's "Natural History of Staffordshire." A rare local work. Very curious. I am tempted to mention it, though perhaps it strictly does not belong to the list.

"Botanology. The English Herbal or History of Plants, by William Salmon, M.D., 1710." Dedicated to the Queen. Containing, relating to each plant, the names, kinds, descriptions, places, times of flowering, the qualities and virtues.

Joseph Miller's "Herbal. Botanicum Officinale, 1722." A little work not often met with.

Sir Hugh Plat's "Garden of Eden," a rare little work.

"The British Herbal," by John Hill, M.D. A work much to be praised, based upon the labours of Ray, Tournefort, and others. Illustrated by beautiful steel plates. Fine tall copy here, 1756.

In "Alibone's Dictionary," I find mention of no less than seven hundred and ninety works on botany.

I may be excused for mentioning the name of an eminent man who, though but little known as a botanist, still takes no mean place among the ardent and proficient students of this important science. I refer to the late John Stuart

Mill. He says, in his Autobiograpy, "his strong relish for accurate classification was brought about by his study of botany." His short communications on botany were chiefly, if not exclusively, published in a monthly magazine called the "Phytologist." In the early numbers of this periodical will be found frequent notes and short papers on the facts of plant-distribution, brought to light by Mr. Mill during his botanical rambles. He was a keen searcher after wild plants. It is believed from the mass of notes and observations it was his intention to print them as a foundation to a "Flora" at Avignon, the place where he so long resided and where he is laid. Mr. Mill left his herbarium to the gardens at Kew.

I must, in concluding my list of worthies, mention two names of gentlemen in our county, members of our club, who have contributed in no small degree to the Literature of Botany — Mr. Bateman, in his valuable work on "Orchidaceæ," and our esteemed friend Mr. Garner, our companion and mentor in many of our pleasant botanical rambles, in his charming book the "Natural History of Staffordshire," and other works.

I may perhaps in this paper have dwelt too long upon classification, and the growth, as a science, of botany, to the exclusion of a more attractive and deeply-interesting phase of the subject; I mean the poetic and legendary interest that is so closely attached to it.

There is hardly a familiar wilding in our hedges and brook sides that does not call to mind some poem or fragment of folk lore. Indeed, many of the old English names, which I hope may never be lost, often tell their own story. If I have succeeded in interesting you at all

in botanical studies from the side especially taken to-night, the relation of the results of my acquaintance with the tall folios of earlier botanists (which I now invite you to inspect) will not altogether have been made in vain.

THE GEOLOGY OF MOW COP, CONGLETON EDGE, AND THE SURROUNDING DISTRICT.

BY J. D. SAINTER.

After having had the honour and privilege of conducting the geological investigation of this locality so far, and having pointed out and explained some interesting sections of the different strata we have passed over, probably it will be as well if I enter a little further into the subject, since I daresay some of my hearers are strangers to this neighbourhood. In the first place I would remark there is not much doubt these gentlemen will have already perceived during our ramble that the red rock fault plays a very important part in the geology of this district. This fault commences a little to the north of Stockport, cuts right across East Cheshire, in almost a direct line, and terminates at a point near Talk-on-the-Hill, Staffordshire, a distance of thirty miles. Along this line of break, nearly throughout its whole length, there is a very remarkable contrast in the physical features of the country, owing, for the most part, to the difference in geological structure. Its eastern aspect consists of the carboniferous strata, forming lofty hills with bleak and barren moorland, bold escarpments, and sharp cliffs, which are varied by deep dells and long, broad, basin-like valleys ; while immediately upon the western side of the fault we stand upon the well-wooded and highly-cultivated Triassic plain of Cheshire,

which is only at a small elevation above the sea in consequence of its soft rocks having been almost planed down to a level service. With respect to the character of the country further east, above described, there is another point of view connected with it that may be named. This tract forms the component part of a section of that central ridge which stretches 200 miles from Derbyshire northwards to the borders of Scotland, generally known as the Pennine chain, or backbone of England. It marks the position of a great anticlinal axis, from which on its western side have been thrown off the coal measures of Lancashire, Cheshire, and North Staffordshire ; and on the eastern side the coalfields of Yorkshire, Derbyshire, and Nottinghamshire. This upheaval has attained its greatest developement in North Derbyshire, where the immense central arch of mountain limestone has been brought to the surface with an elevation of 1,500 feet above the level of the sea. With respect to the lithological structure of this hill (Mow Cop), which forms the base of the lower coal measures in the Biddulph valley, it is identical with the strata that crop out in the Flintshire coalfield, after having formed a synclinal axis across the Cheshire plain which is overlaid by the new red sandstone deposits ; and at a future day it is said that these may have to be sunk through, in order to reach the available coal measures, which are calculated to be at a depth of 4,000 feet below the surface. During our tour of inspection, after having descanted more or less upon the petrological character, &c. of each section that has engaged our attention, I have little more to add on those points, except in occupying the short time we have to spare in making a few observations not altogether devoid of local interest. The following rock formations enter into the composition of Mow Cop and its vicinity :—The upper part of the hill consists of the first and third beds of the

millstone grit, which assume the form of a saddle on its western aspect, so that lower down the hill the Biddulph coal measures rest upon it. Below these, leading down towards the railway station, about one quarter of a mile from it, the division between the coal measures and the new red sandstone is distinctly seen crossing the road, and forming what is called the "red rock fault" of this part of Cheshire. Proceeding northwards on a line with the railway as far as Grotto Wood Farm, and in a lane close by to the left, the same circumstance is clearly shown, namely, dark coal shales on one side of the fault and soft mottled sandstone on the other. About one mile still further north, close by the Lime Kiln Farm, we come to a singular and almost unique affair in witnessing an upheaval of the carboniferous limestone nearly to the surface, through all its superincumbent strata, with a throw, it is said, of 8,000 feet. This mass is dome-shaped, displacing the lower keuper sandstone to the west and the Yoredale rocks eastward. There is 2,000 feet in thickness of these rocks striking up the hill, which assists in the formation of Congleton Edge, and the lower division of them, for some distance from the boss of limestone, has nearly a vertical dip arising from the excessive squeezing they were subject to during the disruption of the surrounding strata. Towards the summit of the Edge they are overlaid by the first and third beds of the millstone grit, which, along with them, dip at a very acute angle to the south-east, and form the coal basin of the Biddulph trough. The bold ridge which is observable eastward on the opposite side of this valley (a distance of about three miles from Biddulph Moor,) consists of the outcropping of the same strata I have just described, namely, the first and third beds of the millstone grit with the Yoredale rocks lying below them. These grit beds are very persistent in this district, since from

Mow Cop along Congleton Edge northwards there runs a thin belt of them, about six miles in length, which terminates at Cloud Hill; and this is the northern boundary of the North Staffordshire coalfield. The country below Mow Cop is pretty well covered by the glacial drift, and a few patches of it are to be seen about the Brook Houses, leading up to the Edge, which contain marine shells at an elevation of 600 or 700 feet above the sea. In the forest of Macclesfield, 1,200 feet above the sea, we have some rather large spreads of the drift, in which are found about 20 species of marine shells. In the Cemetery ground, which is 500 feet above the sea, nearly sixty species have been picked out of the drift beds. I have pointed out the seam of coal lying between the first and third grits on Congleton Edge, which is four feet in thickness, of an inferior quality, and is used for the burning of lime, &c. The second bed of grit is absent in this district. At Macclesfield it exists near the One House, &c., in great force, with a small bed of coal lying below it. This grit is traceable as far as the back of Swithamley Park, where it dies out. The third bed of grit is at Macclesfield, about 200 feet in thickness, with a bed of coal lying on the top of it, as Tegsnose, &c. The first bed of grit is 100 feet in thickness, with coal lying towards the bottom. It thins out beyond Wetley. The thickness of the two grits, with the shales and coal seam on this edge, will be near upon 300 feet. The fourth grit is 100 feet thick at Macclesfield, and it is seen no more beyond Biddulph Moor. It forms the table land of Kinderscout, North Derbyshire, and is there verging upon 1,000 feet in thickness. Of the fifth bed there is 60 feet at Macclesfield, and it terminates at a point near Rushton. In Lancashire these millstone grit beds are largely developed, having a total thickness of 2,500 feet. The whole of them, as you will have heard, gradually

diminish in thickness, and die out proceeding southwards. The Macclesfield grits with their shales are 1,000 feet in thickness, north of Biddulph 600 feet, and west of it 400 feet in thickness. Across the red rock fault, east of Macclesfield, besides the grit coal we have likewise the tail end of the Lancashire coal measures; these consist of four or five poor thin seams, of which the third is the best for household purposes. In the Biddulph Valley both the middle and lower coal measures are worked. As I have before stated, the Yoredale series of rocks, which lie immediately below the grits, have been brought up by the Astbury lime kiln fault with a throw or thickness of 2,000 feet. On the western side of Shutlingslow, owing to an upcast fault, they will have a throw of about 1,500 feet. We have probably 1,200 feet of them near Macclesfield. The upheaval of those Yoredale rocks, forming the anticlinals of Bosley Minn and Gun Hill, is 1,200 feet above the sea. To the east of Biddulph Moor there is an anticlinal of the Yoredale rocks, which from the shattered state of the strata appears to have been formed under great disturbance. Like the grits, these rocks become thinner proceeding southwards, and it is said that they extend no further than the Leicestershire coalfield. As I have pointed out before, the fault at the Astbury lime works has a probable maximum throw of 8,000 feet. The nearest approach to the surface we have of the Buxton limestone, near Macclesfield, is to be seen in the forest at Saltersford. Here, in a line with the anticlinal axis of this part of Cheshire, the carboniferous limestone will probably lie at a depth of about 1,500 feet below the surface. The red rock fault, as I have named before, skirts the town of Macclesfield at a distance of one quarter of a mile to the east. Several fine sections of this fault are to be seen between Mow Cop, Congleton, and Macclesfield, of a very

interesting character. At the latter place some wells have been sunk through the drift beds (150ft.) down to the rock, or the second Bunter sandstone of the Trias. Two of these wells have borings into this rock to the depth of 100 feet, when a copious supply of excellent water has been the result. About half-a-mile south of Macclesfield, near the Copper Works, owing partly to a transverse fault across the country to Alderley Edge, northward of this fault for some distance, all the red marl and second keuper sandstones have been removed by denudation in former ages, leaving that space occupied by the 150ft. of drift deposits upon which the town of Macclesfield is chiefly built. After crossing this fault and the eastern border of Danes Moss, the railway rests upon the red marl almost all the way to the Mow Cop station, with the fault in close proximity on the left, and during its formation, when cutting some sections through the superficial drift beds near Congleton, marine shells were discovered.

FOSSILS OF THE CARBONIFEROUS STRATA ABOUT MACCLESFIELD.

Only calamites and aviculapecten in the black shales of the Yoredale rocks in Ratcliffe wood. In the third grit—sandstones, lepidodendron, calamites, stigmaria, sigillaria, conifers, halonia with dendritic impressions. In the roofs of some of the small seams of grit coal are found goniatites and aviculapecten. In the lower coal measures—sandstones on Kerridge, calamites, conifers, equisetums, halonia, favularia, ferns, ulodendron, bothrodendron, lepidodendron, stigmaria, sigillaria, and traces of fucoids with impressions of raindrops, traces of annelids and ripple marks. In the shales of the lower coal measures—aviculapecten, goniatites, anthrocosia, lingula, scales of fish, and

ferns in nodular ironstone. There will be fossils in the middle and lower coal measures of the Biddulph coalfield characteristic of them. On Congleton Edge—aviculapecten and goniatites between the two grits, and about a dozen species of fossil shells have been found in the Yoredale rocks.

Probably it will be of interest to enumerate the heights in feet above the level of the sea of some of the chief points about here. Cloud Hill, third grit, 1,190; Mow Cop, first grit, 1,100; Roches, near Leek, third grit, 1,580; Shutlingslow, first grit, 1,718; Cat and Fiddle, first grit, 1,780; Axedge, 1,809; Tegsnose, third grit, 1,300; Northern Nancy, Kerridge, lower coal measures, 930; Eddisbury Hill, lower coal measures, 1,000; the Gun and Bosley Minn, both of the Yoredale series, 1,200 feet; Alderley Edge, new red sandstone, 650 feet.

ON THE ABSENCE OF WATERFALLS IN THE SCENERY OF NORTH STAFFORDSHIRE.

BY J. E. DAVIS.

Of the various applications of an acquaintance with the physical structure of a country or district not one appears to me to be so attractive as that which enables us to read the history of a landscape. In the more minute investigation into organic structure, whether of past or present life, our sense of the beautiful in nature is sometimes—perhaps often—lost sight of, or is at least perceived with obscured powers of vision; but in the contemplation of a view it cannot diminish our appreciation of its grandeur or its grace to know why one line is rugged and another curved—why we have an elevated tract here and a deep gorge there.

It is, moreover, a good mode of testing our knowledge of general principles of science to cover the page of external nature laid open to our view at any particular spot with notes of interrogation. The endeavour to obtain accurate answers to these questions often teaches us also how to observe correctly, and not to be satisfied with mere guesses.

One of the questions occuring to me when my eyes have wandered over the scenery of North Staffordshire has been this—"Why are there no Waterfalls?" and this question I ask your kind assistance this evening in solving.

Do not suppose that the question indicates any dissatisfaction akin to that of the Greek without his sea, or any desire to depreciate the charms of North Staffordshire. I love a waterfall with an intensity of feeling wholly incapable of expression, and possibly this affection has led to the enquiry; but I am not insensible to other beauties, nor am I conscious of any feeling of dissatisfaction with the development of natural charms under any conditions, even on the plain of Cheshire or in the fens of Lincolnshire.

This by way of preface: now for the question, "Why are there no Waterfalls in North Staffordshire?"

Let us consider what are, at a first glance, the apparent essential component parts of a waterfall. A stream of water and a rock. No one will deny the abundance of water in North Staffordshire. Some may say there is too much; others may say it is not always to be met with when and where they desire to have it; but of the ample natural supply no one can doubt. Look at our charming rivers the Trent, Dove, Manifold, and Churnet, and their minor tributaries. So of rock there is abundance, even in the immediate neighbourhood of Stoke-upon-Trent. We cannot go by railway from Stoke into Cheshire on the north or into Shropshire by way of Market Drayton on the west, without passing through or under rocks. We have them in highly picturesque forms at Mow Cop, The Roches, and at Swithamley, at Congleton Edge, and Cloud, and also on a smaller scale in travelling by road or by railway from Stoke to Leek, and at Wetley Rocks; and these are only a few among numerous other examples. But you may say, "Very true; but water and rocks are not in *combination* in these spots." Well observed, but explore

the valleys of some of the streams already mentioned. The Dove, and the Manifold, and the Churnet meet this observation at once. The great charm of these valleys consists in the intimate union of rock, water, and wood.

It may be said, "Yes, there are hills and dales and rocks and water in North Staffordshire, but the elevation is insufficient to produce falls. Waterfalls are inseparably associated with mountainous countries." In reference to this suggestion I may say here that in speaking of "Waterfalls," I have merely in my mind those smaller gems of beauty which fill up the charm of our island in Wales and Scotland and in the Lake district of Cumberland and Westmorland, and form points of attraction for the tourist and excursionist; and, undoubtedly, although those districts comprise points and lines of watershed of much greater elevation than any in Staffordshire, nearly all these falls occur at heights above the sea level, inferior to the elevation of Staffordshire towards its northern boundary.

Take, for example, falls probably known to most visitors to Llandudno—the Fall of the Conwy on the old Shrewsbury and Holyhead road a few miles above Llanrwst; and the Swallow Fall (Rhairdr y wenol) on the Llugwy, on the road between Bettws y coed and Capel Curig; and the Fall at Aber, between Conwy and Bangor (a momentary glance of which may be caught from the passing train); or that most graceful of North Wales Falls—Rhairdr ddu (the Black Cataract) near Maentwrog in Merionethshire; or the highest fall in Wales—Pistil Rhairdr in Denbighshire (within the drainage of the Severn). In all these cases the tumble of the water occurs at a very few hundred feet above the sea level. The same observation applies to the Falls at the Devil's Bridge, and in the Vale of Neath

in South Wales, and to Lodore, Ara Force, and Scale Force in Cumberland, and many others equally well known. The foot of the largest fall in our island (as regards volume of water)—the lower Fall of the Clyde, is only a few feet above the line of high water. In North Staffordshire we have, as I need not remind you, an extensive area of from 500 to upwards of 1,700 feet, with springs and streams issuing from a few feet of the summit.

The question therefore is not so idle when put in reference to the existing physical geography of North Staffordshire, as it would apparently be if asked in reference to the plain of Cheshire or of North Shropshire. If a fellow-passenger by railway in passing from Crewe to Warrington or from Crewe to Shrewsbury asked us if there were any waterfalls to be seen between those spots, we should smile at the notion. We should no more look out for falls there than when looking down from the summit of Antwerp Cathedral on "the lazy Scheldt." Not so with the traveller in North Staffordshire. If a passenger by the Churnet Valley Railway asked me, in passing between Alton and Cheddleton, if there were any waterfalls in the neighbourhood worth visiting, I should rather infer that he was a person of observation, although of not much local knowledge. With the rapid stream, deep gorge, and peeps of distant hills he might naturally expect to receive an affirmative answer. If he had the Ordnance survey spread out before him, he might even reasonably express surprise at my reply in the negative, for he might point on the map to the village of "Waterfall" on the one hand and to "Waterfall Cottage" near Endon on the other. I could however assure him with truth that North Staffordshire cannot boast of a Lilliputian fall equivalent even to those pretty toys of dame Nature's baby-house —

Shanklin, and Black Gang Chine, in the Isle of Wight.

What then is the law governing this branch of physical geography or geology, whichever term you like to apply to the subject of enquiry? We know it is not chance or caprice that regulates the presence or absence of a waterfall any more than the presence or absence of any other natural phenomenon. "Freaks of nature" are terms unknown to naturalists. We know that material laws are so unchanged and unchangeable that the fact, once ascertained, that there is no perpendicular fall of water in North Staffordshire of, say, fifty feet, is equivalent to saying that there could not by any possibility, consistently with the other natural local phenomena in present or past times, be such a waterfall within that area. Can we so decipher the past and present condition of things as to read the answer that exists beyond doubt to the question which I now repeat to the North Staffordshire Field Naturalists—"Why are there no Waterfalls in North Staffordshire?"

I only venture to make a few suggestions by way of indicating the direction in which the solution is to be sought. From the moment the embryo stream trickles in drops from a spring on the hill side, it is engaged in one task; not strictly in "hastening to the sea," as Longfellow poetically expresses it, but rather in descending to the sea level in the shortest possible course, a vertical line; not content with escaping down the natural or original face of the hill, at an angle determined by causes independent of and beyond its own control, it is for ever cutting, and pounding, and tearing away the hill side. It is obvious that if the angle of what I have termed the original face of the hill is the same from the summit to the foot, and the material of the hill itself is of uniform consistency or

hardness, the action of the stream will be uniform, or at least only varied by increased velocity, and acquired volume from contributory streams, in the course of descent. The result would be a rapid stream at a gradually increasing angle, but without any sudden jump of the water. If, on the other hand, the stream has a varying substance to traverse, or, in other words, to work upon, the character of the stream must inevitably change with it. If, after traversing a hard rock, it passes over a soft one, it will in a given time have made a deeper score in the soft than in the hard rock, and in the course of time, at the points of junction, or passage from the hard rock to the soft, a sudden depression will be produced; in other words a waterfall of greater or less height. In North Staffordshire what substance have the hill streams to traverse? The answer, applicable to the principal portion of the area, is, a coarse sandstone, known geologically as the Millstone Grit. It is not of uniform consistency and hardness, for nearly every quarry varies, as every quarryman will tell us. The variations are frequent, from a sandstone to a grit, and from a grit to a conglomerate. Still, the one general character of a grit applies to it, and the changes in texture are not of that decided, determined character which abound in other elevated districts of England. The millstone grit in North Staffordshire is free from hard intrusive rocks of igneous origin. There are none of the hard trap dykes that abound in Wales and in the North of England, but the variations are of that limited kind just sufficient to produce slight variations and changes of aspect. Such is the character of the watershed of the infant Churnet and Weaver, and, extending our area of observation beyond the confines of the county, such is the character of the streams descending from the millstone grit in other parts of England. In Derbyshire, where this

formation attains a greater elevation, giving rise (in conjunction with the mountain limestone) to beautiful scenery of rock and water, there is a marked absence of waterfalls. Our worthy friend and admirable local historian and naturalist, Mr. Garner, speaks, I observe, of the small rivers in the valleys in the northern parts of Staffordshire, as "forming occasionally fine cascades over the grit rocks." I am confident, nevertheless, that he will not regard my statement as inconsistent with his record of actual facts. But what part do the trap rocks in Wales play in the production of waterfalls? The mudstone rocks and grits of Merionethshire and Carnarvonshire are interlaced with stratified porphyry, and these hard bands stand up like artificial walls across the beds of rivers and streams. In vain the water has waged a perpetual warfare against its antagonist. Its ambition is doomed to incur a fall! It is now a quarter of a century since I was first struck with this natural history of the waterfalls of North Wales. After an instructive visit with Professor Sedgwick in the summer of 1846, I returned in the autumn to work out the succession of beds between Bala and Snowdon, and I could now, without reference to sections or maps, point out numerous illustrations of the connection existing between waterfalls and the lines of trap rocks. I shall, however, now only refer to the fall of the Conwy, before mentioned. There a basaltic dyke has stopped the scooping out process of the river, and caused the fall. I invite any members of this society who may visit Llandudno in the coming summer to test this for themselves. In another way, although less direct, the existence of beds or walls of hard rock tends to produce waterfalls. These falls, as we have seen, are the result of the incessant action of water for countless ages. Constant action denotes a constant supply of water. This is only effected by natural reservoirs

—by the mountain lake or tarn, or by the elevated bog (acting like a sponge), reposing on high table lands. These resources are very frequently caused by a succession of hard beds, forming as it were the edges of the basin and husbanding the supply. If there is no hard rim the edges are in course of time worn away; and so, on the other hand, if there is only one hard line or ridge, the water falls as from the sides of the roof of a house, and there is no constant supply. The Malvern Hills are an illustration of the latter state of things. The principal rock—syenite—is hard enough, but as the hills are the result of one line of abrupt elevation (dividing Gloucestershire and Worcestershire on the east and south from Herefordshire on the west), and of subsequent denudation, the rain water flows off at once from the axial line, and there are no natural store-houses for streams, and no waterfalls, and the district is scantily supplied with water, as most residents and visitors become painfully aware. On the higher ridges of North Staffordshire, although there is no such axial line, the sandstone edges of the original basins have been weathered down, and there are few elevated natural pools to be met with—none of any large size. For an example of a natural basin keeping up a constant supply of the mechanical power—water—to saw through and scrape away the softer materials in its course, I may refer to Llyn Conwy, a lake which probably no member of the North Staffordshire Field Naturalists' Club ever saw, as it lies in a remote district, out of sight of any road, and possesses no attraction beyond those incident to a sheet of water with wild, weather-beaten boundaries. It is the parent of my dearly-beloved river Conwy, and is a natural basin on table land at a very considerable elevation, with its edges formed by the igneous rock. If, therefore, I were compelled to answer the question myself in concise

terms, I should be inclined to say that the reason why there are no waterfalls in North Staffordshire is because there are no alternating beds of trap or other hard rocks to interfere with the gradual descent of streams from the hills. I must, however, not be misunderstood. I do not say that rocks of a decidedly varying composition are essential in all cases to produce waterfalls. They may be caused by dislocations, by faults and joints in beds of the same lithological character, severing their continuity. Still, I believe those instances are exceptional. Joints and faults oftener serve as apertures through or down which streams flow, than to cause falls. These rents have, as it were, anticipated or saved the mechanical action of the water itself. These latter remarks seem to apply to the absence of waterfalls from that part of North Staffordshire where the substratum is not millstone grit, but mountain limestone. That formation, as Mr. Garner in his Natural History of Staffordshire has more than once observed, is full of extensive fissures and cracks, through which, as we know, the water often flows beneath the surface, as in the case of the Manifold and Hamps streams. In South Wales there are waterfalls under as well as above ground in the rivers and streams passing through this limestone. Again: there are some waterfalls that do not appear on a first inspection to illustrate the operation of any of the general laws above mentioned. I will refer to two instances. In Scale Force, the well known fall in Cumberland, the water has evidently sawn its vertical way into the horizontally-bedded hill side, at right angles with the main valley. The less known fall in South Wales, bearing the quaint name of "Water-break-its-neck," has apparently also sawn or eaten itself through horizontal Upper Silurian beds. Their history appears to be this: the valley into which the streams flow having been excavated by water

when the whole was under the sea level, the fluvial action began as the sea-worn escarpments emerged. The adjacent valleys may or may not have been filled with gravel. If they were so filled, then these instances form no exception to the general course of operation, the streams having washed away the gravel and laid bare the cliffs down which they then tumbled, and then began the slower process of cutting into the rock.

With the preceding observations thrown out, merely suggestively and not dogmatically, I conclude. Although inquiries of this kind, affecting the aspects of nature in this our day, relate to the action of laws operating only since the last elevation of the land above the sea, the history of a waterfall is the history, as far as we can discern, of a period of vast duration. The question of the recession of falls opens a wide field, but without travelling out of our own island, I firmly believe that there are traces of action by falling water for years the number of which are inadequately represented by our modes of computation, although extended to millions and billions and trillions. If this be so, how are we to form any conception of the distance separating us from geological epochs so far removed, that compared with them a waterfall is but as a creation of yesterday?

THE MISTLETOE.

BY THOS. W. DALTRY, M.A.

THE MISTLETOE, or viscum album, as it is called in science, is a plant full of interest to all, both from its well-known Christmas associations and from its own peculiar habits and growth. In a grave assembly of naturalists like the present, the latter is of course the subject on which I propose to address you this afternoon.

The chief interest, then, of the mistletoe centres in this, that it is the only true parasitic plant of the British Isles: all the other so-called parasitic plants, such as the orobanches, the cuscutas, the lathrœa, &c., are but semi-parasitic, and indeed hardly so much as that, for these all have their roots in the earth, although at the same time always growing in and among the roots of those trees and shrubs to which they are peculiar; but the mistletoe is a true parasite: it never has anything to do with the soil except through the branches and roots of the tree on which it occurs.

The mistletoe is a diœcious plant, that is to say, the stamens and pistils are contained in separate flowers, and those flowers are on different plants, so that you will in vain look for berries unless you have the male and female plants within a reasonable distance of each other. The root is thick and woody, growing deeply into the branch

on which it has fastened, and spreading to a considerable distance under the bark. The stem, which is dichotomous, is much forked into numerous round green branches, each year's shoot being readily distinguished by means of a slight swelling at its base, so that it is not difficult to ascertain the age of the plant. The branches are brittle, easily breaking at the point of junction of each year's growth. The leaves are in pairs, leathery, flat and smooth, scarcely ribbed, obovate or oblong lanceolate, from one to two inches long, and from each pair spring the young shoots, two in number, each with its own terminal pair of young leaves: the old leaves are shed in September after the perfect developement of the new ones. The flower buds are formed in the autumn, just before the old leaves fall off, on the young shoots of the same season: they occur both at the top, between the terminal pair of leaves, and also (especially in the case of the female plants) at the base, at the point of contact with the shoot of the previous year: they expand early in the following spring, in mild seasons as early as March; they are in triplets, the normal number of these triplets at the base of the shoot being four, while at top, in the axis of the leaves, there is never more than one. The flowers are insignificant in appearance, of a somewhat yellower shade of green than the rest of the plant, the male flower being the larger of the two, with fleshier and more pointed petals: the calyx is obsolete: the petals are four in number, and ovate in shape, and in the case of the barren flower each bears about its middle a sessile anther; the stigma is single, and also sessile. The fruit is round, in colour milk-white (hence the *specific* name), pellucid, and contains but a single heart-shaped seed enveloped in glutinous matter (hence the *generic* name *viscus*): it seldom ripens in this country till December, and remains on the plant

until the young berries of the following season are beginning to develope themselves, which does not take place until about midsummer, some eight or ten weeks, that is, after they are set: then the unfertilized germ falls off, and the future berry begins to swell. In this way both ripe berries and flowers, or even the succeeding crop of berries, though as yet you may not distinguish them from the abortions, are co-existent on the same plant. The mistletoe is a free flowerer, and readily sets its fruit: indeed, so far as my experience goes, it has never failed to produce an abundant crop of berries.

As to the manner of propagation, it is no doubt carried about by birds in those localities where it grows freely in a natural state. The berries are said to be a favourite food of thrushes, blackbirds, &c., but I have only known them to be taken once, and that was in a very severe winter, when other berries had become scarce. On that occasion the thrushes in a very few days, not more than two or three, I think, had completely stripped off every berry. In other winters they have not so much as looked at them. This, however, may probably be owing to the mistletoe not growing naturally in North Staffordshire, and the birds have consequently not acquired a taste for its berries. The generally accepted theory is, that the berries having passed through the intestines of the birds uninjured, and being stimulated to germination in their passage, are ejected, and in some cases happen to fall upon branches of trees suited for their growth; and as from the berries bird-lime can be made, this theory has given rise to the doggrel rhyme—

"The thrush, when he pollutes the bough,
Sows for himself the seeds of woe."

I am, however, more inclined to think that in pulling the berry from the plant the bird's bill sometimes bursts the husk, and the glutinous matter in which it is enveloped causes the seed to adhere to the sides of the beak or head, and the bird naturally wiping off the stickiness upon the branches of the trees on which it alights by striking its beak to and fro (as indeed you may often observe them doing,) deposits the germ of the future mistletoe plant. This, I feel confident, is the true explanation of the natural propagation of the mistletoe. The seed is soft, not hard, and so far from being uninjured in its passage through the bird, would more probably be assimilated.

But the mistletoe may readily be introduced into fresh localities by the simple process of sowing it, not however in the soil, as in the case of most plants, but upon the branches of those trees which it affects. The *modus operandi* is this: break open the berry, take out the seed, and throw the husk away; select a branch of the tree on which you wish to have your mistletoe plant; the cleaner and smoother the bark is, the better; certainly it should be free from moss or lichen; and on it, or rather under it, place the seed, which will at once adhere by means of the glutinous matter which envelopes it: on no account make a slit in the bark to receive the seed. No doubt that is the plan usually recommended in botanical works, but experience teaches that it altogether fails in practice, and a moment's thought will shew the reason: the bark being wounded naturally begins at once to direct all its vigour to healing the wound, and in the process of healing throws off the seed, or rather perhaps refuses to admit its germination, and the seed consequently withers away before it can take root. It is advisable also to sow in dry weather, if possible, as wet has a tendency to reduce the consistency

of the glutinous matter, the adhesive power of which is thereby impaired, and the seed slips down the branch, or hangs suspended in mid air by a slender thread, which when dry becomes brittle and is easily snapped. Spring frosts, too, have the same effect: the morning sun, then attaining considerable power, speedily thaws the rime which covers everything exposed to the atmosphere, and bathes it in abundant humidity. It is therefore well not to sow till May or even June; then you will soon observe the seed to put forth one, two, or three (never more than three) green fang-like shoots or radicles, which late in the season may be noticed to be already extruded from the seed within the as yet unbroken husk. These forthwith direct themselves towards the branch, on which the seed is fixed, and in the course of the ensuing twelve months succeed in penetrating through the bark into it. Then the shoot (or shoots, as the case may be,) appears to detach itself from or thrust off the shrivelled and empty skin of the seed, and now becoming the stem of the first year puts forth a pair of green leaves. In some cases, however, the leaves do not make their appearance for two or even more seasons This, perhaps, arises either from the top of the shoot having been accidentally rubbed off, or from its having been eaten away by insects, but all the time the root is growing and expanding under the bark, which visibly swells, and when at length the plant emerges it breaks out into several shoots, each with its pair of young leaves. Flowers do not appear until the fourth year at the earliest; generally not until the fifth or sixth year of growth.

There are one or two peculiarities of the Mistletoe which ought to be noticed here. The first is, that the radicle always

tends toward the centre of the branch, on whichever side the seed may happen to be fixed. This law, which appears to be constant with this parasite, is contrary to that of all other seeds of plants, which put out their radicles and tend towards the centre of the earth, and not towards the centre of the object on which they happen to grow. Another peculiarity is, that, fix the seed to what you please, whether to a living branch, or to dead wood, or even to an iron nail, the radicles will grow out and meet it, and will for a time remain fresh and green; nor, in fact, will they entirely perish until the ensuing spring.

Now one word as to the kinds of trees on which it is found to grow. As everyone knows, it is most frequently found on the apple, yet it grows equally well on the hawthorn, the service-tree, the poplar, the lime, the willow, and perhaps also the mountain-ash; but not upon the oak, the tree of all others which it is popularly supposed to affect the most. I have tried it, year after year, under the most favourable conditions, on healthy young oak trees; I have sown it on shoots, and branches of different years' growth, but though the seed will as usual put forth its radicles, just as it will upon a rusty nail, they refuse to penetrate the bark, and dry up and perish by the following spring. No doubt it is the tan in the bark of the oak which is at fault. Some years ago there was a discussion in the Gardeners' Chronicle on this very point, and I well remember that two persons stated that they had either seen it themselves actually so growing, or else had been told so by others; I forget exactly which, but the impression left on my mind was that there was quite room enough for misapprehension. At any rate,

if it grows on the oak—and I would go a considerable distance to see it—it is very scarce, and in that case it must have been its very scarceness which caused the Druids of old to worship and venerate it when they found it.

The large quantities of mistletoe which make their appearance at Christmastide in the markets of our cities and towns are in a great measure derived from the Continent, where it is abundant, especially, I believe, in Normandy. In England, the south-western counties are most famous for it. That it will grow in North Staffordshire which I believe has hitherto been looked upon as somewhat doubtful, I have only to say to the members present, *Circumspice.**

As to the name, which is variously spelt *mistletoe, misteltoe, misletoe, missletoe, misseltoe,* the derivation is doubtful, and is given differently by different etymologists. Perhaps as good as any is that given in Chambers's Dictionary, where it is derived from "*mistel,* which is probably the Latin *viscus,* bird-lime, and *teinn,* Anglo-Saxon *tan,* a twig or sprout;" or the latter part of the word may be *ta* or *toe,* being that part of the bird which is caught by the birdlime. The Anglo-Saxon form of the word is *mistelta*; the German, *mistel*; the Icelandic, *misteltein.*

*Note.—This paper was read in the Vicarage garden at Madeley, where many plants of mistletoe may be seen growing luxuriantly on apple, hawthorn, &c., all of which have been raised artificially. A single female plant has flourished there for many years, but berries have only been obtained some eight or nine years, a considerable interval having elapsed after the the first plant was raised before a fresh sowing was made.

The Mistletoe belongs to the natural order *Loranthece,* and in the Linnean system to Class xxii., Diœcia; Order ii., Tetrandia; Genus iv., Viscus.

AN OUTLINE OF THE HISTORY OF ENGLISH MEDIÆVAL ARCHITECTURE, ILLUSTRATED BY STAFFORDSHIRE EXAMPLES.

BY CHARLES LYNAM.

I HAVE undertaken, at the request of our indefatigable Honorary Secretary, to sketch out for you this evening an "Outline of the History of English Mediæval Architecture, illustrated by Staffordshire Examples." It may appear to some members of our club that this is a subject somewhat foreign to the strict object of the association. If this be so, I beg to remind such that very soon after the formation of our society it was decided that archæology should come within the scope of our pursuits, and I need hardly say that at our summer excursions the remains of ancient buildings in this and other counties have been a frequent source of attraction.

Again, I have fancied a smile to cross the countenance of some as the word "Mediæval" passed before them in the notice of this meeting, as one cannot but remember that in minds of a certain training the strongest association with the period is as of darkness—intellectual, religious, moral ; and as sure as the term mediæval is brought before them, so sure does that of the "dark

ages" occur to them. But architecturally there could not be a greater mistake than to think or speak of these times as dark. For, suppose for a moment that our Cathedral of Lichfield were destroyed; where would be the glory of this county's architecture? Or suppose the wondrous piles of Durham, Winchester, Norwich, and Gloucester; the beauties of Salisbury and Westminster, and the western front of Wells; the Minsters of Lincoln, Peterborough, and York; the Royal Chapels at Windsor and Westminster, and King's College Chapel at Cambridge, and the Colleges of Oxford—I say, suppose all these mediæval buildings to be thrown down, would not England indeed be bereft of her architectural glories and become truly American? So that architecturally speaking, at least, the times regarding which I am to address you to-night demand our respect and admiration.

To come nearer to the subject, it will be convenient for me to define at once precisely the period of time over which our observation is to run, namely, from the date of the Conquest by William the Norman, in 1066, to the death of Henry VIII., in the year 1545, embracing very nearly five centuries.

Of works prior to 1066 there are none in this county that I am acquainted with, unless it be a fragment or two of Roman walls which will not detain us now, and what are known as the Runic monuments in the Churchyards of St. Peter's, Wolverhampton, Chebsey, Checkley, and Leek. The first of these was treated of in detail during the late visit of the British Archæological Association to Wolverhampton, and after careful examination of those at Checkley and Leek I can come to no

other conclusion than that these too are of the same period as that ascribed to the one at Wolverhampton, namely, Early Norman. That they are of Christian origin there can be no doubt, but as our sketch is to be a general and not a detailed one, I will say no more now of these particular works except to remind again, as I have done before, any of our friends who may come from Leek, that against the eastern wall of their churchyard lie, I will not say uncared for, but certainly subject to the will of any one inclined to be mischievous, relics of the past not less than 800 years old, relics as interesting to the antiquary as anything that can be named as belonging to this county. In mentioning this I cling to the hope that the question may be raised in Leek whether it would not be worth the while of those justly proud of their town and of those zealously interested in their church to consider the propriety of re-erecting these ancient monuments.

I have said that the period over which I propose to travel this evening embraces about five centuries, and the first fact I wish to impress upon you is, that during the whole of this time, not only in England but in the greater part of western Europe, but one style of architecture prevailed, namely, that which is now commonly known as Gothic; and this uniformity of style not only extended to the larger cities and towns but also to every village and indeed to every building that was erected, whether ecclesiastical or civil, throughout the land. In those days there was no difficulty as to the choice of styles. Travellers had not then brought their sketches, nor persuaded their countrymen to the adoption of their fancies from Egypt, China, Greece, or Rome, but as

their faith was one so was their architecture, and not only architecture but all its accessorial arts of floor-laying, glass-painting, metal-working, and mural decoration; all breathed one spirit, all had but one object, all aimed at but one end, and that the best they could produce in a given style. To this of course must be attributed in a great measure their wonderful success.

This uniformity of practice did not, however, produce a constant repetition, but, on the contrary, endless and charming variety. Change was specially marked by four distinct phases of work commonly distinguished as—1st, Norman; 2nd, Early English; 3rd, Decorated; 4th, Perpendicular.

The Norman began in 1066 and lasted 123 years, starting with William and continuing through the reigns of William II., Henry I., Stephen, and Henry II., ending in 1189. The Early English period continued from the last-named date through the reigns of John, Henry III., Richard I., and Edward I., to the year 1307. The Decorated period prevailed for seventy years, comprising the two reigns of Edward II. and Edward III., and ending in 1377. The Perpendicular period, commencing at the last-named date, continued through the reigns of Richard II., Henry IV., Henry V., Henry VI., Edward IV., Edward V., Richard III., Henry VII., and Henry VIII., lasting for about 170 years, and ending in 1545. In a debased form this last style continued for about 100 years later.

There are throughout England distinct examples of each

of the foregoing classified periods which the archæologist is as well able to distinguish as is the naturalist the classes of plants, animals, insects, or fossils; nay, further, within our own county there are most interesting specimens of each of the four periods. I may go a step still further and say that each of the five hundreds which formed the ancient division of this county contains examples alike beautiful and interesting. I might almost say that there are several churches which in themselves exhibit traces of every change of Middle Age style. Thus, in the Collegiate Church of Gnosall, between Newport and Stafford, we have features characteristic of each period and every transition of style which occurred during the 500 years of which we are speaking; and the same may be said of that reposeful old church of Checkley, in the valley of Tean Brook. So also of the large parish church of Tamworth, and perhaps of St. Peter's, Wolverhampton, but this last has undergone the process of restoration and in consequence has lost much of its charm to the antiquarian. Of course a better example than all these would be our gem of a Cathedral at Lichfield, but I purposely abstain from referring specially to it as its charms and attractions are known to everyone, whilst the humble yet interesting parish church is frequently passed by as not meriting time or study, and it is to these that I desire more particularly to direct your attention, in the hope that for the future they may for some of you be a greater source of interest and pleasure. It is for this reason, too, that the examples selected for illustration have been chosen from this class of buildings.

It will be gathered from what has been already said

that our subject is to be narrowed to ecclesiastical examples, as those of civil buildings are extremely scarce in this county. The Castles of Tamworth and Dudley are the only ancient ones now in any way inhabited, those of Chartley, and Heleigh, and Tutbury being mere ruins. The old bridge across the River Trent at Burton is now being pulled down, and soon will be lost to us its varied forms with its picturesque effects.

It will therefore be necessary in the first place to remind you of the several features which go to make up the fabric of a church, and then proceed to point out the characteristics of these features in the several subdivisions of our subject. First, to refer to the arrangement of plan. The main point here, throughout the whole period, has been the separate accommodation for priests and attendants, and for the people. To this rule there is not any exception. The chancel or eastern portion of the church, where the holy rites had to be administered, was always planned as a separate part of the whole church, and the place for the people was attached to it westward. The former part is called the chancel and the latter the body of the church. These two portions were always screened from one another. The remains of these ancient screens exist in all parts of this county, as at Blore, Madeley, and Swinnerton. The chancel is generally of ample dimensions: the floor raised above the level of the body of the church, the eastern termination being in this county generally flat, with the exceptions of the Cathedral of Lichfield, the Abbey of Croxden, and the late example of Barton-under-Needwood, which are apsidal. The body of the church took various forms: 1st, the simple parallelogram; 2nd, the nave

and transepts forming, with the chancel, a Latin cross; 3rd, the nave with one or two aisles, the last being the commonest plan, as seen at St. Chad's, Stafford, and by that of Checkley, as here illustrated; 4th, nave and aisles, with transepts, as seen by the plan of Madeley. Private chapels were often added at the east end, as also shown on the plan of Madeley. In addition, there are commonly either north or south porches, or both, and a tower which is usually placed at the western end of the nave, as at Checkley and Madeley; but in Norman work the tower was commonly placed at the junction of nave and transepts, as at Lapley, Gnosall, and St. Mary's, Stafford. Occasionally the chancel has one or more aisles, as at Kinver, and in rare instances a room is provided over the porch, as at Penkridge, and in the case of Clifton Campville over a north chapel or transept. These rooms seem to have been used either as a library for the books of the church or for a dwelling for a monk, and there is generally about them a trace of domestic character, particularly noticeable in the example of Clifton Campville.

Before leaving the question of plan it ought to be mentioned that in almost every churchyard in this county there are remains, more or less perfect, of the churchyard cross, generally placed to the south of the church. Specimens of each period may be mentioned:—Leek, of the Norman (if this be granted me); Rocester, of Early English; Blithfield, of Decorated; and Biddulph, of Perpendicular. I only mention single places, but in fact, as I have said, scarcely an old churchyard in the county exists without them, and this feature alone would form an interesting subject for an archæological

discussion. The lych gate (where the bodies of the deceased were first received preparatory to interment) was also a provision of our forefathers, but this county possesses but few ancient examples. Being in the company of naturalists, I ought not to omit to mention the almost invariable custom of the old builders placing a yew tree (emblem of eternity) on the site of their burial places. As with the churchyard cross, so with the yew—its knarled and hollowed trunk, its hard and closely-grown branches, with its evergreen foliage, always appears in the midst of the ancient place of sepulture of our forefathers. In some places it is of prodigious size. It was only the other day that the vicar of one of our country parishes pointed to the hollow of an immense trunk of a yew on the borders of his church-yard, saying to me that an old villager used to stable his donkey within it. Some of these trees must be centuries old, and if any naturalist present could discover a method of correctly estimating their ages at varied growths he would help towards the settlement of many vexed antiquarian questions. For instance, if any one could state the precise age of the yews in Rushton churchyard, perhaps a more correct history of that church would be arrived at.

The plan of the parish church was of course enlarged upon in that of the abbey and cathedral church, but of these I do not propose to speak, excepting to remark that in them the chancel became the choir, and there were usually added a Lady Chapel at the east end, as at Croxden and Lichfield, and that chapter house, cloisters, and domestic offices were also added. At Lichfield, it will be remembered, there are no cloisters, but the

remains of them at Croxden Abbey are complete enough.

The fittings of an ancient parish church should not go unnoticed. They consisted, in the chancel, of an altar against the east wall; sedilia, or seats for the clergy, in the south wall; piscina, where the altar vessels were cleansed; aumbrye or cupboard, where they were kept; and stalls for the clergy, and singing men and boys. As there is so little antiquarian interest in these Pottery towns, and as one has to mourn the loss of the ancient parish church at Stoke, I may mention that within the present churchyard there the outline of the old church may be clearly traced, and that a relic of great price as yet remains there. The stone altar slab still lies there *in situ*. It is of Early English date, and on its front edge are the mouldings of the upper part of the capitals of the shafts which supported it. At Lapley, the sedilia of Early English date remain, and those of Decorated character at Cheddleton, Bushbury, Norbury, and other places. Choir stalls arranged after the ancient fashion are to be seen at Blore. The only fittings of the body of the church of which examples remain are the font and benches or seats. Of the former, many specimens remain of very ancient date, as at St. Mary's, Stafford, Maer, Rushton, Blore, and elsewhere. Of seats there are remains at Blore, Mavesyn Ridware, Madeley, and elsewhere. Bells of ancient date still hang in many of our old towers, and they are features of immense interest, most of them bearing beautiful inscriptions marking distinctly the date of their manufacture.

Of monuments in memory of the faithful departed I dare not speak, lest they should tempt me to an utter

diversion from our subject, so interesting, beautiful, and varied are they.

Next to the arrangement of plan may be considered the sectional parts of a church. These consist of walls, with their windows, doorways, buttresses, and parapets; arcades, separating aisles from nave or chancel, with or without a clerestory; roofs varying in pitch and construction. These are features which prevail throughout the whole period, but their treatment varies in a marked degree in each division, and I proceed now to point out their several characteristics. In doing this I propose not to confine myself to any particular feature, but to speak of them generally, as I am better able to illustrate them by the examples at hand. First, of the wall and what belongs to it. Norman walls are always of great thickness, and their faces are always built of small stones; often the height of these is greater than their length. Small stones continued to be employed during the Early English and Decorated periods, but in the last or Perpendicular times large stones were used often of great length and of considerable height. Walling is not generally considered important as distinguishing works of the different dates, but I have found the study of the different kinds of common masonry as useful as any other feature, or more so, in determining the age of ancient buildings. Often the more prominent features are so disguised as to puzzle your scrutiny. For instance, you may find a tower with buttresses, base moulds, and string courses of late date, and confining your observation to these you would naturally put the whole as coeval, which might of course be incorrect. I would mention the towers of Forton, near Newport, and Checkley, as having been altered in this

fashion, and without acquaintance with the particular treatment of common masonry mistake as to date would ensue in these instances. The old masons were in the habit of marking their wall stones with distinguishing characters, and throughout all Middle Age works these marks are to be seen: whether they were individual or guild marks we will not now stop to discuss. Walls mostly have bases in projection from their common face above the level of the ground, and these differed in each of the several periods. The Norman base was either a simple square projection or a beveled one. The Early English rose some distance up the wall and spread at the foot, as at the tower of Checkley and the chancel of Pattingham. The Decorated base rose high up the wall, and mostly consisted of an upper and lower moulding, the top edge of the latter being mostly simply beveled off, as in the chancel at Checkley and the north aisle at Madeley. The Perpendicular wall base became a still more prominent feature, sometimes reaching almost to the sill of the windows and consisting of several members, as in the tower of Brewood, Penkridge, and elsewhere.

Next we come to the Buttress, which was an external projection of the wall intended to give it additional strength. This in Norman work was broad on the face and shallow in the projection, running mostly in one height from its base to its sloping top immediately under the parapet. In Early English work the buttress loses some of its width but gains in projection, and in small buildings is often treated rather as an ornamental adjunct than as an additional stay to the wall. This is seen in the restored east end of Weston Church, and in that of Pattingham, of which a drawing is here. In Decorated work the buttress

became narrower, but of still greater projection, and had more sets-off or stages in it, as at Checkley. Sometimes its sets-off are treated ornamentally, being run into pediments and finished with carved crockets. In Perpendicular work the buttress is still more ornamentally treated: its tablings are moulded, its faces sometimes paneled and at others niched, often terminating in pinnacles having carved crockets at their angles, as in the tower of Penkridge. Norman and Early English buttresses were always placed at right angles to the wall they abutted upon, but in Decorated times a change took place by placing corner buttresses angle-wise, as at Swinnerton, Arley, and in many other places. This continued through Perpendicular times, as at Penkridge.

Next we come to the Parapet or upper finish of the wall. In the Norman times, this is always plain, being supported on projecting corbels often carved into heads and other grotesques, the coping being simply moulded. In Early English work the parapet is still plain and supported on corbels, simply shaped, but not carved, and the coping plainly moulded. In Decorated work the parapet becomes pierced, either in the form of tracery, as at Draycot, or of battlements. In Perpendicular work the parapet is always pierced, and almost invariably in the form of battlements, as at Checkley, Penkridge, and many other places. Parapets have been added to very many churches in Perpendicular times, and if they be taken as a guide to the date of a building without consideration of the wall they cover, mistaken conclusions will certainly ensue.

We now come to the openings in the walls, consisting of doorways, windows, and archways, and these are

features which perhaps more strikingly distinguish our several divisions than any other. These openings are generally arched. In Norman work the arch is almost but not entirely round, and this is generally considered the characteristic of this period.

You all remember the western doorway of that fine old church under Tutbury Castle, with its enriched semicircular arches receding order after order and finishing in its inner circle with an alabaster ring carved in a manner far superior to any thing that can be done even in these days. As an example of building geology, this inner arch is a great curiosity, showing that alabaster as an external material most delicately carved has stood the action of a clear Staffordshire atmosphere for 800 years. Some of you may also have noticed the southern doorway of this same church, which is also characteristic of this period, having semicircular arches considerably enriched and boldly recessed. The remains of these southern doorways of Norman times are not uncommon in this county, and are valuable as at once fixing the foundation of the church as a remote one. Thus they are to be seen at Waterfall, Blore, Maer, Codsall, Stowe, and elsewhere, including White Ladies, of which there is a sketch here. Early English doorways are not common in Staffordshire, but there is one at Gnosall, at Croxden, and at Stapenhill. Decorated doorways are common enough, as at Checkley, with the ball flower ornament, Cheddleton, Norbury, Clifton Campville, Tamworth, &c. Perpendicular doorways are also common, as at Brewood, King's Bromley, &c. Of the arch between chancel and nave we have several Norman specimens, as at St. Chad's, Stafford. There is one of very highly enriched character at Longdon, near Lichfield, and there are others

of great simplicity at Gayton and Waterfall. Perhaps the main distinguishing feature between Norman work and that which succeeded it is the form of arch, which changed from the semicircular to the pointed. This form varies from a rise just higher than a semicircle to an equilateral, and beyond this to an acutely-pointed form. Of the Early English chancel arch we have not many Staffordshire examples. The western tower arch at Weston is, however, a very good specimen. Of Decorated chancel arches there are many, as at Over Arley on the banks of the Severn, Checkley, Madeley, and Clifton Campville. Early in the Perpendicular period a new form of arch arose, and is one of the strongest marks of this style. It is known as the four-centred arch, and is well illustrated in the western doorway of Brewood, of which we have a sketch. It is of frequent use not only in minor but in large arches. This form occurs in several chancel arches in this county.

Of the arches used in the arcades between nave or chancel and aisles we have next to speak, and with them we will also take the piers on which they are carried. The arches in the Norman period are semicircular, simple, and massive in their construction, and cannot be better illustrated than by the example at Tutbury of which we have at sketch here. They also occur at Enville and at St. Chad's, Stafford. The sketch showing the west wall of the south transept at Gnosall gives further explanation of the style of arcade employed by the Norman builders. The circular form of the arch, the simplicity and massiveness of its parts, are apparent. The transition from Norman to Early English in this point is admirably shown at Checkley, where the arches, though pointed, are treated in the simplest possible manner. Of an Early English arcade

we have a very perfect example in that of Weston church, shown also by a sketch. Of Decorated arcades very many examples exist, as at Madeley. They mostly consist of two orders of arches, splayed or moulded on the outer edge, and are generally enriched by a hood mould. Of Perpendicular arcades there are also many examples, as at Brewood, Alrewas, and elsewhere; and here the four-centred arch is often used, and its mouldings consist principally of hollows, the hood mould not being often employed.

Of the Pillars supporting these arches, those of the Norman period are mostly round and massive compared with their height, as at Tutbury. The transition from Norman to Early English is clearly shown at Checkley, where the shaft has become comparatively slender and its form varied on plan. The Early English pier is either circular, octagonal, or multiform, and is well illustrated at Weston. The Decorated pier is generally octagonal, but sometimes round and multiform, as at Over Arley, Tamworth, and elsewhere. The Perpendicular pier is generally of slender proportions, and is sometimes octagonal and sometimes multiform, having large hollows in the inner angles of its plan. Of the caps and bases to these piers I need say but little, but in Norman work the caps are of simple character. In Early English they become elaborately moulded; in Decorated, carving is often introduced into them; whilst in Perpendicular times they are not unfrequently ornamented with small battlements. Bases to piers follow the manner of those of walls, before referred to. In Norman and Early English work they are simple in form, but in Decorated and Perpendicular they rise considerably up the pier and are more or less elaborately moulded.

It remains for me now to draw your attention to the Windows. These in Norman times almost invariably had rounded arches and were of single lights, the glass being placed very near to the external face of the wall and the internal thickness was widely splayed, sometimes enriched with shafts, as at Tutbury. The Early English window was that known as the lancet, following in principle its predecessor in having wide internal splays and its glass near to the outer face, the arched head being of course pointed and not round. These lancets were either single or were placed two or three or more together. The chancels of Eccleshall and Brewood have good examples of these windows. Also those of Gayton, and of Pattingham and Croxden, of which we have drawings here. The conjunction of these lancet windows gave rise to those used in the next period. A very interesting example of this transition is afforded by a fragment from Stoke old church, which I happened to meet with amongst broken materials forming the foundation of a hay-stack not far from the town. You will see by this sketch that the process of change has been thus :—Two lancet lights have been brought together with only a slight division (called a mullion) between them, and in the space between the arches of their heads a sunk panel has been formed. A similar window to this occurs in the monks' room over a north chapel at Clifton Campville, of which we also have a drawing. The next step was to pierce this panel and glaze it, and then we arrive at once at the two-light Decorated window, as at Swinnerton. Having a window constructed in this way, the multiplication of its lights followed as a matter of course, and the tracery in their heads gradually became developed. At first it was treated in simple geometrical forms and plainly, as at Swinnerton.

As time went on, and the builders sought after change, this tracery became elaborated into any form that pleased the fancy of its designer, but rarely if ever did it miss being beautiful. Of the windows of this period we have very many examples, some of them very remarkable, as at Checkley, where the wall is very largely pierced for its windows, no doubt for the internal display of their painted glass, of which a considerable portion now remains. At Norbury, near Eccleshall, at Wichnor, Elford, Cheddleton, Leek, Bushbury, and Stretton (of which last we have a drawing) there are beautiful examples. Indeed, they may be said to abound throughout the county. Lastly, we come to the Perpendicular window, which is distinguished by the great size to which it attained and by the lines of its divisions or mullions running perpendicularly from sill to head. These windows range from two lights up to nine, and often nearly fill both gables and flanks. They are sometimes crossed by a horizontal bar, called a transome, which is frequently ornamented with the ever-present battlements. Almost every ancient church possesses windows of this character. The very large ones in the south transept of Lichfield Cathedral and in the west gable and clerestory of St. Mary's, Stafford, will occur to everyone. Indeed it would appear to have been a main object of the builders of this later age to turn the more ancient walls as far as practicable into glass. They took out every other style of window and inserted their own. They built clerestories which might have given rise to the idea of the first Crystal Palace of 1851. And perhaps some will say they were a befitting notification of that great spiritual and intellectual light which shone upon this nation at the time at which my sketch is to close.

I have not spoken separately of the towers and spires for lack of time, but we all know that there is nothing in the kingdom to vie with the triple spires of Lichfield; and those of Brewood, Clifton Campville, Weston, and Church Eaton are very beautiful. The towers of Penkridge, King's Bromley, and many others are of their dates excellent specimens. The tower of Burslem church is the oldest bit of architecture we have in the Pottery towns, and it is to be hoped our mother town will cling to her ancient possession.

Briefly to review the characteristics of the several Middle Age periods, I would summarize them as follows:—Norman: The prevalence of the round arch and massiveness and simplicity of its several parts, its Staffordshire types being Tutbury, St. Chad's, Stafford, Enville, Gnosall, and Tamworth. Early English: A chastened elegance combined with real strength and simplicity, the chancels of Eccleshall, Brewood, and Pattingham being examples. Decorated: The combination of a controlled force bespeaking a perfect art, as at Lichfield, Norbury, and Wichnor. Perpendicular: Luxuriance, which ended in the decay and ultimately the extinction of Middle Age architecture.

I have now tried to bring before you in as short a time as possible a view of that architectural genius which prevailed during five centuries of England's past, as seen from the lesser monuments of our own county, and my hope is that as a result none here will in future consider that the grey and weather-stained walls of our most rambling, straggling parish church are unworthy of their interest and concern; but will remember that the piers and arches, walls and roofs which have resounded

the prayers and thanksgivings of ages past are still the places where our own spirits may worship the one God of past and present; and that you will all join with me in embracing the sentiments of him who wrote—

> "Where'er I roam in this fair English land
> The vision of a temple meets my eyes;
> Modest without; within, all glorious, rise
> Its love-enclustered columns, and expand
> Their slender arms: like olive plants they stand,
> Each answering each in home's soft sympathies,
> Sisters and brothers. At the altar sighs
> Parental fondness, and with anxious hand
> Tenders its offering of young vows and prayers.
> The same, and not the same, go where I will,
> The vision beams! Ten thousand shrines, all one.
> Dear fertile soil! What foreign culture bears
> Such fruit? And I through distant climes may run
> My weary round, yet miss thy likeness still."

ON THE ORGANIC REMAINS OF THE COAL-MEASURES OF NORTH STAFFORDSHIRE, THEIR RANGE AND DISTRIBUTION, WITH A CATALOGUE OF THE FOSSILS AND THEIR MODE OF OCCURRENCE.

BY JOHN WARD, F.G.S.

SINCE the formation of the North Staffordshire Naturalists' Field Club, papers treating upon special branches, chiefly of the fauna of the coal-measures of North Staffordshire, have been brought before the notice of the members, but no attempt has hitherto been made to catalogue the fauna and flora as a whole. It must not be understood that the present lists represent the whole of the organic remains of these coal-measures, but they are complete so far as our investigations have at present extended. Before a more comprehensive list can be given, a more exhaustive search will be required in the various fossiliferous strata. This is especially the case with the flora: a more careful search would add many species not recorded in our list.

The fauna of these coal-measures have for many years occupied the attention of several observers, special consideration has been given to the fossil fishes, and a large series has been collected which will compare favourably both in variety and extent with those from any of our British coalfields. In the coal-measures of North Staffordshire we have represented most of the genera which occur in the

Scotch, Lancashire, and Northumberland coalfields. There are many species found in these coalfields yet wanting in and ours: we have on the other hand many species which have not been found elsewhere.

To the palæontologist, the coal-measures of North Staffordshire are full of interest from the character and extent of their organic remains. Many of the rocks and shales which intervene between the various seams of coal and ironstone are full of fossil plants, which testify to the luxuriance of the vegetation which flourished during their formation. Nor were the ancient carboniferous seas devoid of animal life. Fishes of strange forms, very different from those we are accustomed to see at the present day, peopled the waters of that remote period. Mollusca of various species inhabited the seas or rivers, and of the abundance of these creatures sufficient evidence is shown in many of the shales. To the thoughtful and intelligent student of natural science, these remains are of special interest. To him, they are the silent relics of a by-gone creation. They carry his mind back into the mysterious past, and afford him a glimpse of the great work of creation, by which beds of coal and ironstone were formed and laid up in the storehouse of nature for man's future use and comfort. As the coin or the inscribed stone dug up from some ancient ruin helps the antiquary to read much of the history of the past, so fossils are to the geologist as so many guides to help him in his identification of strata and their position in the series, as well as their age. A careful study of the organic remains of a particular district would, we think, help the practical miner in the correlation of beds in various parts of the coalfield. Many of the seams have characteristic fossils. These, if rightly

studied, would afford valuable datum-lines in mining operations. It must, however, be borne in mind that the seams of both coal and ironstone vary considerably in different parts of the district. So marked is the change that many of them are not recognisable even within a short distance. There are, however, many seams which are distinguished either by their proximity to some well known bed, or by particular fossils which render their identification easy.

We would urge upon all those specially interested in mining pursuits to carefully note the organic remains, together with any other striking peculiarities they may meet with in the sinking of shafts or other mining operations. These, if properly studied, cannot fail to be valuable auxiliaries in the correlation of beds in districts of which little is known.

The coalfields of North Staffordshire are as follows:—First, that known as the Pottery coalfield. Second, the Wetley and Shafferlong basis. Third, the Cheadle and Ipstones coalfield. Fourth, the small coalfield of the Roaches. They comprise an area of between 70 and 80 square miles. There are between forty and fifty workable beds of coal and many of ironstone. Many of these beds are of great value. The Pottery coalfield is bounded on the north and east by ridges of millstone grit, and on the south and west by Permian strata. It is triangular in form, the apex resting near Congleton, and gradually expanding to a width of twelve or fourteen miles, as measured from Longton in the east by Newcastle and Apedale to the western boundary. At the present time, operations are being carried on which, if successful, will

extend the boundary in the eastern portion of the coal-field. A shaft is being sunk at Great Fenton. A considerable thickness of upper measures, not recognized at Longton, has been passed through, containing several thin seams of coal and ironstone, underneath which the various seams lie in their regular and natural order. At Lightwood, about a mile and a half distant to the south, a bore-hole has been made to a depth of 250 yards, and numerous beds of coal and ironstone have been passed through. These trials are of great interest and importance. They prove beyond doubt that the coal-measures of the district will be found in their natural order underneath a considerable tract of country beyond the limits of the hitherto known and workable coalfield. The Wetley and Shafferlong coal basin extends from Wetley Abbey on the south to Deep Hay on the north. In length it is about three miles, and about one mile in breadth. It contains one or two thin beds of coal of little commercial value. At the present time it is not worked. The Cheadle and Ipstones coalfield is about four or five miles in length, and about six miles in breadth. It is surrounded on the north by grit rocks, and on the south by Bunter conglomerate. It contains several good seams of coal, and at the present time is being well developed. The lower measures of the Churnet Valley contain a valuable and remarkable bed of hæmatite known as the Froghall ironstone, which forms the base of the coal-measures, resting upon a bed of clay a few feet above the mill-stone grit. The little coalfield of the Roaches and Axedge is about five miles east of the town of Leek. It contains six or seven workable beds of coal, but no ironstone of commercial value.

The coal-measures of North Staffordshire have been divided by Mr. Smyth into four distinct parts as follows:— First, the upper measures down to the top Red mine ironstone, representing a probable thickness of 1,000 feet. Second, the Pottery coal and ironstone measures down to the Ash or Rowhurst coal, from 1,000 to 1,420 feet in thickness. Third, lower thick measures, including the Winpenny coal, thickness from 1,400 to 2,400 feet. Fourth, lowest measures, including the Wetley and Biddulph coal, probably 800 to 1,000 feet. The whole form an aggregate thickness of from 4,200 to 5,620 feet.

The upper measures contain many fossil plants. Very fine specimens of Stigmaria occur in the Red mine and Bassy mine ironstones. Fish remains are rare, being almost confined to detached teeth of which Diplodus gibbosus, Ag., is the most common. The most characteristic shell is Anthracomya Phillipsii, immense quantities of which are found in the ironstones.

The second division contains between forty and fifty seams of coal of an aggregate thickness of fifty yards, and seventeen or eighteen bands of ironstone. It is somewhat remarkable that the principal ironstones are all found in the upper division of this coalfield. In the South Staffordshire and Derbyshire coalfields they occur in the lower divisions. The only beds of ironstone of importance in the lower thick and lowest measures are the Cockshead and the valuable hœmatite of the Churnet Valley.

In this division we find a remarkable bed of fresh-water limestone, about 2 feet 6 inches thick, which is generally found about twelve yards above the Bassy mine ironstone.

It contains great numbers of a small annelid (Spirorbis carbonarius), and affords a valuable datum-line to the underlying measures. Similar beds, but much thinner, occur near the Newcastle tunnel, Hartshill, and Blurton, but whether they represent distinct bands is not yet quite clear. In the Warwickshire, Shropshire, and South Wales coal-fields similar beds of limestone are found, and at Ardwick, near Manchester, there is a bed much more largely developed. This affords a clear proof that important changes took place over a wide extent during the formation of these coalfields. At Shelton Colliery the Gubbin ironstone contains many fine specimens of teeth of several species of fishes. Teeth of a rare reptile (Pteroplax cornuta) (see plate, fig. 1) are occasionally found in this bed.

Passing over a number of coal seams the shales of which contain but few organic remains, we come to the Deep mine ironstone, one of the richest stones in the eastern part of the district. At Longton it is worked to a greater extent than in any other part. It has a fine black laminated shale, which contains many perfect fishes, of which Palæoniscus is the characteristic genus. It contains one new genus (Cycloptychius); also fine specimens of Cœlacanthus, Amphicentrum, and Acanthodes. Detached teeth of Megalichthys and Diplodus are not rare, and occasionally specimens of Sphenopteris Hoeninghausii and a new species of pecopteris with serrated edges are found. At Shelton, this bed does not appear to be rich in organic remains. The Rusty mine and Chalky mine ironstones are rich in several species of fishes. At Fenton, a fine jaw, teeth, and a large portion of the head of a rare reptile (Pteroplax cornuta) have been found in the latter bed. About 12 yards below this bed there is a bed of sandstone containing mineral tar.

The New mine ironstone at Longton is not rich in fossils. At Kidsgrove it contains a rare species of shell (Anthracomya pumila). At Fenton, a remarkable bed of ironstone, called the New ironstone, but locally known as the Rag mine, was worked extensively a few years ago. It contains the most curious collection of fish remains of any bed we are acquainted with. Specimens of the rare fin-spine of Orthacanthus, eighteen inches in length, have been collected from this bed. The Brown mine ironstone of Silverdale and Apedale contains similar fossils, and there is a strong resemblance in the character of the shale which goes far to prove their identity. It is, however, a noticeable fact that the latter bed contains many perfect fishes, while those of the former bed are fragmentary. Platysomus, Amphicentrum, and Rhizodopsis are the most characteristic genera of fish of the Brown mine.

The Knowles or Winghay ironstone is rich in fossils. The shale resembles that of the Deep mine, not only in colour and texture but in the general character of its organic remains. There is, however, one striking difference, that while Palæoniscus is the most characteristic genus of the latter bed, Platysomus is of the Knowles. The ironstone occurs in several bands, separated by beds of shale. The upper band contains the greatest number of fish-remains; the lower bands are richest in Mollusca. This division contains two remarkable beds which show the great range in time over which the existence of many of our coal-measure fossils extended. Not only does it show this fact, but it shows that important changes took place during the deposition of these coal measures. The first bed is that known as the Priorsfield ironstone, above which there is a bed of brown-coloured stone containing

large scales, probably of Ctenodi, and numerous specimens of Discina, a true marine fossil. The second bed is the shale which occurs above a thin coal called the Bay coal, which was passed through a few years ago in sinking a shaft to the Ash coal. This bed contains many species of fossils of a marine type, some of which are found in the Carboniferous Limestone, while others are restricted to the coal-measures. They include two species of Lingula, one of Discina, together with Productus, Spirifer, Goniatites, and a species of Palæoniscus, which is also found in the shale of the Stinking coal.

The alternation of marine with beds of fresh-water origin leads us to enquire how these changes were produced. The solution of this problem is difficult. Nevertheless, it is one of great interest, inasmuch as a true solution of the question would help us to understand much that at present is enshrouded in mystery respecting the origin of coal. At present we are acquainted with at least four beds representing as many changes which took place during the deposition of these coal-measures. Not only was this coal-field subjected to these alternations, but similar changes were in operation during the formation of other coalfields. Mr. Prestwich, in his valuable paper on "The Geology of Coalbrook Dale,"* records the alternation of marine with beds of fresh-water origin in the coal-measures of that district. He accounts for their presence by supposing that they were produced by the oscillation of the land, whereby it was at one time submerged and covered with a stratum of silt containing marine exuviæ, and at another raised and converted into a marshy tract, overspread with a thick luxuriant vegetation, and harbouring in its shallow waters numerous fresh-water shells to be again submerged and

* Trans. Geol. Soc., 2nd Series, vol. v.

overlaid by another marine deposit; and also suggests whether the phenomena cannot be accounted for by supposing that the coal-measures were accumulated in an estuary, into which flowed a large river, subject to occasional flushes of water charged with the testacea and the vegetation of the adjacent districts.* At present, the facts adduced are too scanty to warrant the conclusion that the marine beds of this coalfield are correlative to those of other coalfields.

The organic remains of the lower thick measures consist chiefly of plants and mollusca; fish remains are more rare. At a short distance below the Gin mine or Golden twist coal, and underlying a sandy rock, there is a bed of dark shale which contains an interesting collection of marine fossils. In addition to those found in the bay coal, it contains a large species of Nautilus, two or more of Chonetes, together with Goniatites, Nacula, Axinus, and other forms. It is somewhat remarkable that these fossils appear to occupy different levels in the deposit to which they are confined, and are separated from each other by distinct horizons. Thus, Lingula is confined to the upper portion of the bed in question. This mode of occurrence is interesting, and well worth further consideration.

At a distance of about thirty yards below the Gin mine, there is a third marine bed which contains fewer fossils both in regard to species and individuals. They are much more worn than those in the upper bed. The Cockshead ironstone, at Adderley Green, occurs in irregular bands and frequently assumes a nodular character.

* Trans. Geol. Soc., 2nd Series, vol. v., p. 464.

Good specimens of fish are occasionally found in these nodules. The shale above the ironstone is rich in Mollusca, chiefly of the genus Anthracosia, of which several species are common.

Above the Ten-foot coal at Hanley there is a bed, about two feet in thickness, called the mussel bed, composed of fossil shells. It contains several species of the genera Anthracosia, Anthracoptera, and Anthracomya. Passing over several beds of coal and ironstone, the shales of which contain large quantities of vegetable remains, we find the Sparrow Butt or Hard mine coal. The roof of this coal is a light-coloured marl, which is rich in many species of Mollusca. One specimen of crustacea (Limulus trilobitoides) has been found in a small nodule of stone in this bed. The black shale which overlies the coal contains scales, teeth, and bones of fishes, and frequently teeth of Pleurodus. The Bullhurst coal shale at Norton contains abundance of Aviculapecten papyraceus: fish remains are rare.

The lowest measures consist chiefly of sandstone, grit, and dark shales, with eight or nine beds of coal and the valuable bed of hæmatite or Froghall ironstone. About thirty yards above this latter bed we find the Stinking coal, the shale of which is rich in Mollusca: with the exception of detached scales and teeth: fish remains are rare.

With this brief introduction, we will proceed to show the various species which up to the present time have been collected from the coal measures of North Staffordshire. In addition, we append a list showing the distribution of the organic remains through the various fossiliferous strata. It will be seen from this that many species have a great vertical range, while others are restricted

to a comparatively limited range. In drawing up the list we beg to acknowledge the labours of Mr. Molyneux, F.G.S., who, in conjunction with the author, has for some years devoted much attention to the organic remains of the North Staffordshire coal measures.

The various groups of fossils treated of in this paper are included in the following classes, viz., Plantæ, Mollusca, Brachiopoda, Lamellibranchiata, Gasteropoda, Cephalopoda, Annelida, Crustacea, Pisces, Reptilia.

Plantæ.—Although well preserved fossil plants are not rare in this coalfield, they have not received that attention which they deserve. This neglect is probably owing to the large size in which many of them occur, which renders them unfit for cabinet specimens. In addition to this, the opportunities of collecting them do not occur so frequently as in other classes of fossils. The largest portion of them can only be obtained during deep cuttings, or in the sinking of new shafts. The perishable nature of the matrix in which they are found, and the difficulty of naming them correctly, are additional reasons why so few have been collected. Of the larger genera of coal plants, such as Sigillaria and Lepidodendron, many of the former have been found in various localities. During the cutting of the Newcastle railway, specimens upwards of three feet in diameter were found in the tunnel. Large examples were also found during the cutting of the Biddulph Valley railway, at Fenton Low. It will be fresh in the recollection of the members, that several fine specimens of this genus were exposed in a marl-pit at Joiner's-square, Hanley, which were seen during a visit made by the club to that place several years ago.

These were standing upright, and no doubt upon the exact spot on which they grew.

Sigillaria was one of the largest of the ancient carboniferous trees, and helped in no small degree in the formation of coal. In the specimens above mentioned, the original structure of the interior of the tree was not preserved. It appears to have decayed, and as hollow trunks they would long stand exposed to the fury of the elements. The interior was filled with ferns, calamites, lepidostrobus, and other vegetable remains, which must have been washed or fallen in while they stood hollow. Around the base of the trunks numerous ferns and other plants were found, testifying to the luxuriance of the vegetation of that period.

Stigmaria is one of the commonest of our coal plants. Fine specimens are found in the Bassy-mine ironstone. It is common in all our plant-bearing beds, especially in the fire-clays which underlie the different seams of coal.

Perhaps no class of fossil plants occurs in such a beautiful state of preservation as the Ferns, many species of which are abundant. Upwards of 140 species have been recorded from British carboniferous rocks, of which number about forty species have been found in this coal-field. In the Knowles rock, Moss coal rock, Peacock marl, and in a bed of marl near the Yard coal, many fine specimens have been found. Mr. Lunn has collected a fine series from a bed of grey rock which was passed through during the cutting of the railway at Scott Hay, near Silverdale. Specimens in a good state of preservation have been collected at Adderley Green, Longton, and at Fenton. Good specimens of plants are not rare in the

ironstones. The New ironstone or Rag mine contains beautiful examples of Lepidodendron, Sigillaria, and Calamites, many of them showing structure. So far as our investigations have gone, we find that the various genera and species recorded in our list are alike common to the whole of the plant-bearing beds of these coalfields. We know of no particular genus or species which is confined to any special horizon.

Of the great number of fossil plants which have been recorded from British carboniferous rocks, only a small portion have yet been found in these coalfields. This small number no doubt inadequately represents the total number which a closer examination would supply.

In drawing up the following list of plants, we beg to acknowledge the assistance rendered by Mr. Garner in affording us the opportunity of examining his collection of fossil plants from this coalfield, now in the Stoke Museum, and also our obligation to Mr. Lunn, for the valuable assistance he has rendered by furnishing a list of the fossil plants in his collection, from the Pottery coalfield.

FILICES.

Alethopteris lonchitidis (Sternb. Foss. Flora, vol. 2, pl. 153): not rare: Knowles rock, Longton; Fenton.—A. Mantelli: Raven's Lane, Audley.

Cyclopteris digitata (Brong. Foss. Flora, vol. 1, pl. 64): Woodshutts Colliery; Railway cutting, Scott Hay.—C. reniformis or flabellata: Knowles rock; Hollins Wood, Kidsgrove.

Neuropteris gigantea (Sternb. Foss. Flora, vol. 1, pl. 52): not

rare : Railway cutting, Scott Hay ; Fenton ; Adderley Green.—N. cordata (Brong. Foss. Flora, vol. 1, pl. 41) : common in the under clays : Bradwell Wood ; Adderley Green ; roof of deep mine ironstone ; Newcastle Railway cutting.—N., species with serrated edges : rare : Deep mine ironstone, Longton. —N. tenuifolia : Railway cutting, Scott Hay.—N. affinis (Mem. Geol. Surv.) : shale above the Bassy mine : Goldsitch Moss.—N. acuminata (Brong. Foss. Flora, vol. 1, pl. 51) : Railway cutting, Scott Hay.—N. Loshii (Brong. Foss. Flora, vol. 1, pl. 49) : rare : Railway cutting, Scott Hay ; Longton.—N. heterophyllia (Brong. Foss. Flora, vol. 3, pl. 183) : Railway cutting, Scott Hay ; Knowles rock ; Silverdale ; Hanley.—N. Soretii (Brong. Foss. Flora, vol. 1, pl. 50, and Nat. His. Coun. Staff., pl. E, fig. 1) : rare : Fenton.—N. acutifolia (Nat. His. Coun. Staff., p. 465) : rare : Fenton.—N. macrophylla (Nat. His. Coun. Staff., p. 465).

Pecopteris serra (Lind. Foss. Flora, vol. 2, pl. 107) : Knowles rock : Railway cutting, Scott Hay.—P. dentata (Brong. Foss. Flora, vol. 2, pl. 154) : Hollins Wood. —P. Serlii (Brong. Foss. Flora, vol. 3, pl. 202) : not rare : Knowles rock : Goldsitch Moss.—P. obtusifolia (Foss. Flora, vol. 3, pl. 157) : Woodshutts Colliery.—P. heterophylla (Foss. Flora, vol. 1, pl. 38) : Knowles rock.—P. nervosa (Brong. Foss. Flora, vol. 2, pl. 94) : Railway cutting, Scott Hay ; Longton ; Adderley Green.—P. muricata : Knowles rock.

Sphenopteris Williamsonis (Brong. Foss. Flora, vol. 2, pl. 131) : Bradwell Wood ; Silverdale.—S. macilenta

(Foss. Flora, vol. 2, pl. 151), Railway cutting, Scott Hay.—S. catifolia (Brong. Foss. Flora, vol. 2, pl. 156): not rare: Knowles rock; Silverdale.—S. multifida (Foss. Flora, vol. 2, pl. 123): Hollins Wood.—S. affinis (Foss. Flora, vol. 1, pl. 45): Goldsitch Moss; Railway cutting, Scott Hay.—S. serrata (Foss. Flora, vol. 2, pl. 148): Railway cutting, Scott Hay.—S. caudata (Foss. Flora, vol. 1, pl. 48): Adderley Green; Silverdale; Railway cutting, Scott Hay.—S. adiantoides (Foss. Flora, vol. 2, pl. 115): Bradwell Wood.—S. Hoeininghausi (Brong. Foss. Flora, vol. 3, pl. 204): rare: Deep Mine shale, Longton.—S. tenuifolia: Knowles rock.—S. furcata (Brong. Foss. Flora, vol. 3, pl. 181, and Nat. His. Count. Staff.): rare: Adderley Green.

EQUISETACEÆ.

Asterophyllites galioides (Foss. Flora, vol. 1, pl. 25, fig. 2): Railway cutting, Scott Hay.—A. charoeformis (Sternb.): Silverdale; Adderley Green; Railway cutting, Scott Hay.—A. longifolia (Brong. Foss. Flora, vol. 1, pl. 18): Hollins Wood.—A. dubia (Brong. Foss. Flora, vol. 1, pl. 19, fig. 1): Rag mine, Fenton.—A. equisetiformis (Brong. Foss. Flora, vol. 2, pl. 124): Newcastle Railway tunnel; roof of Bay coal, Longton.

Calamites approximatus (Brong. Foss. Flora, vol. 1, pl. 77): common: Silverdale; Kidsgrove; Bignall Wood; roof of Knowles ironstone, Fenton; Adderley Green.—C. cannæformis Schloth. (Foss. Flora, vol. 1, pl. 79): common: in sandstone, Fenton; Rag mine ironstone; Knowles rock; Hanley, and other districts.

—C. undulatus (Brong.): rare: roof of Wood's mine coal, Longton; Fenton.—C. Suckowii (Brong.) rare: Goldsitch Moss.—C. nodusus, Schloth. (Nat. His. County Stafford, p. 464): rare.

Hippurites longifolia (Foss. Flora, vol. 3, pl. 190—191): Newcastle Railway tunnel (Mr. Garner's collection).

Pinnularia capillacea (Foss. Flora, vol. 2, pl. 111): Adderley Green; Railway cutting, Scott Hay.

Sphenophyllum Schlotheimii (Brong. Foss. Flora, vol. 1, fig. 27): Knowles rock; Railway cutting, Scott Hay.—S. erosum (Foss. Flora, vol. 1, pl. 13, and Nat. Hist. County Stafford, pl. E., fig. 2.): Adderley Green.

LYCOPODIACEÆ,

Favularia tessellata (Brong. Foss. Flora, vol. 1, pl. 73, 74, 75): not rare: fine specimens from Adderley Green Colliery; Silverdale; Apedale.—F. nodusa, Bowman (Foss. Flora, vol. 3, p. 192): Longton; Adderley Green; Goldsitch Moss.

Halonia regularis (Foss. Flora, vol. 3, pl. 228): rare: Fenton; Kidsgrove; Silverdale.—H. gracilis (Foss. Flora, vol. 2, pl. 86): Pinnox Colliery, Tunstall; Rag mine, Fenton.

Knoiria Sellonii (Sternb. Foss. Flora, vol. 2, pl. 97): Hanley; Longton; Fenton.

Lepidodendron dilatatum (Foss. Flora, vol. 1, pl. 7, fig. 2): Longton; Fenton.—L. Sternbergii (Foss. Flora, vol.

1, pl. 4): Bradwell Wood; Hanley; Fenton; Adderley Green.—L. gracile (Lind. Foss. Flora, vol. 1, pl. 9): Newcastle Railway tunnel (Stoke Museum).—L. obovatum (Sternb. Foss. Flora, vol. 1, fig. 19): Rag mine ironstone, Fenton.—L. selaginoides (Sternb. Foss. Flora, vol. 1, pl. 12): Bradwell Wood.—L. elegans (Brong. Foss. Flora, vol. 3, pl. 199): common: roof of Moss coal, Knowles ironstone; Fenton; Adderley Green.—L. plumarium (Foss. Flora, vol. 3, pl. 207): Newcastle Railway tunnel (Mr. Garner's collection).—L. tetragonum (Cat. Mus. Prac. Geol.): near Goldsitch Houses, Leek.

Lepidostrobus ornatus (Foss. Flora, vol. 3, pl. 163): Fenton.

Sigillaria elegans (Brong.): common: Knowles ironstone; Fenton; Longton.—S. pachyderma (Foss. Flora, vol. 1, pl. 54): Hollins Wood; Silverdale.—S. reniformis (Brong. Foss. Flora, vol. 1, pl. 57): large specimens in the Stoke Museum from Newcastle railway cutting; fine specimen at the Mechanics' Institution, Hanley, from marl-pit, Joiner's Square; Railway cutting, Fenton Low.—S. organum (Sternb. Foss. Flora, vol. 1, pl. 70): common: Hollins Wood; Knowles ironstone; Fenton; Adderley Green.

Stigmaria ficoides (Brong. Foss. Flora, vol. 1, pl. 31—36): very common in Bassy mine ironstone, Fenton; also in the underclays, Longton, and in various parts of the coalfield.

Ulodendron majus (Foss. Flora, vol. 1, pl. 5): not rare: New ironstone, Fenton; Adderley Green; Knowles

ironstone.—U. minus (Brong. Foss. Flora, vol. 1, pl. 6): not rare: New ironstone, Fenton; Knowles ironstone.

Coniferæ.

Carpolithes sulcata (Foss. Flora, vol. 3, pl. 220): Bradwell Wood.

Dadoxylon Sternbergia: New ironstone, Fenton; Adderley Green.

Trigonocarpum nœggerathi: rare: interior of Sigillaria, Marl pit, Joiner's-square, Hanley.

Mollusca.

The coal measures of North Staffordshire are rich in many species of Mollusca. Of the Brachiopoda, seven genera and about eight species have been found. During the sinking of a shaft at Longton several years ago, marine forms—such as Productus, Spirifer, Chonetes, and Discina were found in the roof of the Gin mine and Bay coals. Previous to this discovery, it was the generally received opinion that marine fossils were restricted to the lower measures of the British coalfields. It is not our intention to enter into the question whether coal is of marine or fresh-water origin: we think the conditions under which coal was deposited were varied. The alternation of marine with brackish or fresh-water beds clearly proves that great and important changes took place during its deposition. We have evidence that during the formation of these coal measures there were periods in which the natural and regular order was interrupted by the introduction of a new

order. The occurrence of marine fossils in the upper measures, in the roof of two thin seams of coal and in no other, is one of the most curious problems which have come under our notice.

Brachiopoda.

Athyris, sp.: very rare: in the roof of the Bay coal, Longton.

Chonetes, sp.: rare: in a bed of grey rock above the Gin mine.

Discina nitida (Phil.): roof of Bay coal, Gin mine; Lower Coal Measures.

Lingula mytiloides (Sow. Min. Conch. t. 19): roof of Bay coal, Gin mine; Lower Coal Measures; Churnet Valley.

Lingula squamiformis (Phil.): roof of Bay coal and Gin mine; Lower Coal Measures; Churnet Valley.

Orthis, sp.: rare: roof of Bay coal, Longton.

Productus, sp.: rare: roof of Bay coal, Longton.

Spirifer Urii: rare: roof of Bay coal, Longton.

Lamellibranchiata.—This class of the Mollusca is divided into two groups, Monomyaria and Dimyaria. Of the first named group, Aviculopecten is the most abundant. In the lower measures, especially in the shale of the Stinking coal, great quantities of this shell occur. It is also found in the Gold-

sitch Moss, Shafferlong, and Biddulph basins. At Knypersley reservoir, the shale which lies between the Winpenny and Four-foot coals crops out and contains a great abundance of Aviculopecten papyraceus. Of the Dimyaria, there are two groups, one, marine and the other brackish or fresh-water. Of the former, Axinus has only been found. The brackish or fresh-water group is represented by the genera Anthracosia, Anthracoptera, and Anthracomya. Anthracosia is the commonest and most widely-distributed fossil : seven or more species of this genus have been found. It first appears in a bed of clay or marl a little above the Millstone Grit, and is found (with the exception of the two marine beds) in all our fossiliferous beds from the lowest to the uppermost. Anthracosia has been referred to different divisions of the bivalve mollusca. Professor King, who gave it its present name, has shown that it belongs to the unio family. The late Mr. Salter was of opinion that Anthracosia was a burrowing shell. In the soft black shale which overlies the Cockshead ironstone at Adderley Green, great numbers of these shells occur. We have frequently found them in this bed in a vertical position. In the Nova Scotia coalfield shells of this group are abundant. Principal Dawson, of Montreal, who has paid much attention to the fossils of this coalfield, is of opinion that they were brackish or fresh-water shells allied to Mytilidæ or to Embryonic Unionidæ. He adds, that "the mode of their occurrence precludes the idea that they were burrowers, but favours the belief that they were attached by a byssus to sunken or floating timber." (Quart. Jour. Geol. Soc., vol. xxii., p. 144). Anthracoptera is represented by five species. It had not such a wide range in time as Anthracosia, being almost confined to the Lower thick measures. In the roof of the Hard mine coal this genus is abundant.

Lamellibranchiata.—Monomyaria.

Aviculopecten papyraceus. (Goldf.): roof of Bay coal and Gin mine; common in the Lower coal-measures; Churnet Valley; Knypersley Reservoir.

Axinus sp.: rare: roof of Gin mine coal.

Ctenodonta gibbosa. (Flem. Geol. Yorksh., pl. 5, fig. 16): Combe's Valley.

Posidonia Gibsoni (Brown): not rare: Stinking coal shale, Lower Measures.—P. Molyneuxii (Salter): Stinking coal shale; Churnet Valley.

Dimyaria.

Anthracoptera quadrata (Sow.): common: roof of Hard mine coal, Adderley Green; Knowles ironstone; Fenton.—A. triangularis: rare: roof of Hard mine coal, Adderley Green.—A. Brownii (Salter): common: Ten-foot coal, Hanley.—A. carinata: Knowles ironstone; Fenton; roof of Hard mine coal, Adderley Green.

Anthracosia robusta (Sow.): not rare: Moss coal rock, Longton; New mine, Kidsgrove.—A. acuta (Sow.): very common in the shale which overlies the Cockshead ironstone, Adderley Green.—A. Aquilina (Sow.): common in the Cockshead ironstone, Adderley Green; "Mussel bed," Deep Pit, Hanley; Hard mine coal, Adderley Green.—A. lateralis (Brown): Deep Pit, Hanley; Hard mine, Adderley Green.—A. ovalis (Mart.): common: Hard mine, Adderley Green;

Ten-foot coal, Hanley; Holly Lane coal; Banbury coal.—A. Gerardii (Brown): rare: Knowles ironstone; Fenton.—A. subconstricta (Sow.): Gubbin ironstone, Hanley; Moss Rock, Longton; Hard mine, Adderley Green; Kidsgrove; Fenton.

Anthracomya modiolaris (Sow.): Hard mine, Knowles ironstone, and Adderley Green.—A. Phillipsia: Little mine, Longton; Ten-foot coal, Hanley; Chalky mine; Gubbin ironstone; Burnwood ironstone, Hanley.—A. subcentralis: Knowles shale; Fenton.—A. Adamsii (Salter, Iron Ores, part iii., pl. 2, fig. 7): fine specimens in the Burnwood ironstone, Hanley; Knowles ironstone; Fenton.—A. Wardi (Salter MSS.): Hard mine; Adderley Green.—A. pumila (Salter, Iron Ores, part iii., pl. 2, fig. 10): rare: New mine, Kidsgrove; Knowles ironstone; Fenton. —A. dolabrata (Sow., Geol. Trans., vol. 5, pl. 39, fig. 9): rare: Knowles ironstone; Fenton.

Axinus, sp.: rare: roof of Gin mine.

Sanguinolites: Hard mine, Adderley Green; Black band, Apedale.

Gasteropoda.—This class is represented by about seven genera, which are very rare. They occur chiefly in the roof of the Bay coal and Gin mine coals, to which beds they appear to be confined.

Gasteropoda.

Chemnitzia, sp.: rare: roof of Gin mine coal.

Euomphalus, sp.: rare: roof of Gin mine coal.

Loxomma, sp.: rare: roof of Gin mine coal.

Macrocheilus (Phillips): rare: roof of Bay coal, Longton.

Naticopsis, sp.: rare: roof of Gin mine coal.

Platyschisma, sp.: rare: roof of Gin mine.

Pleurotomaria, sp.: rare: roof of Gin mine coal.

Cephalopoda.—This, the highest class of Mollusca, is represented by four genera and about twenty species. Of these, Goniatites are the commonest. This genus is not rare in the lower measures. The highest range in which we have found it is the roof of the Bay coal, in which bed it is of small size. The Yoredale shales are rich in several species of this genus. Good specimens of G. bilinguis have been collected from these beds at Cellarhead, during the sinking of a shaft in a fruitless attempt to reach the Froghall Hœmatite. Of the genus Orthoceras, there are several species not yet identified.

Cephalopoda.

Goniatites Looneyi. (Phil.): rare: roof of Bay coal, Longton. —G. Listeri (Mait.): Yoredale shales, Cellarhead; Bay coal, Longton.—G. Gibsoni. (Sow.): Felt House, near Leek.—G. bilinguis (Salter): Yoredale shales, Cellarhead.—G. excavatus (Phil.): Yoredale shales, Tittesworth Reservoir.—G. obtusus: Yoredale shales. —G. reticulata (Phil.): Yoredale shales.—G. striatus (Sow.): Yoredale shales.—G. truncata (Phil.): Yore-

dale shales.—G. micronatus (Phil.): in brook course, The Combes, Felt House.—G. paucilobus: roof of Bay coal, Longton.—G. intemidius: Yoredale shale, Cellarhead.

Nautilus falcatus (Sow.): roof of Bay coal, Longton.—N. subsulcatus (Sow.): The Combes, near Leek.

Orthoceras cintum (Sow.): The Combes, near Leek.—Orthoceras: roof of Bay coal, Gin mine; Lower coal measures.

Discites falcatus: roof of Bay coal and Gin mine.

Annelida.—Of this group only two genera have been found, viz., Spirorbis and Serpula. All the recent species of Spirorbis are marine in their habitat. It is a curious fact that the extinct species are only found in beds of freshwater origin. At a short distance above the Bassy mine ironstone there is a bed of so-called freshwater limestone, known as the "Spirorbis limestone," in which it is abundant. It also occurs in many of the coal shales in the upper as well as the lower division of the coalfield. We have frequently seen it attached to the stems and leaves of fossil plants, especially ferns, beautiful examples of which have been found at Scott Hay.

Annelida.

Spirorbis carbonarius (Murch.): common: found adhering to plants, Scott Hay; band of freshwater limestone; Upper and Lower measures; Cockshead ironstone; Hard mine coal shale, Adderley Green, &c.

Serpula: rare: Lower Measures.

Crustacea.—Of the various groups into which this class of articulated animals is divided, that termed Ostracoda is the most numerous in this coalfield. These creatures are minute in size and are enclosed in bivalve shells. There are few beds in which they are not found. Beyrichia arcuata (Bean) is the commonest and most widely distributed species. This little creature is easily recognized "by having the valves curiously pinched and divided into two or more lobes by transverse or oblique sulci." Immense numbers are found in the Bassy mine ironstone. Of the higher orders of crustacea, very few specimens have been collected. One specimen of Belinurus has been found associated with marine shells, in a nodule of clay ironstone in the roof of the Hard mine coal at Adderley Green. Mr. Molyneux, F.G.S., has recently discovered a number of Macruran decapod crustaceans (Anthrapalæmon Grossartii) in a thin band of ironstone in the Churnet Valley. One specimen of a rare form of Eurypterus has been found by Mr. Lunn, in a bed of grey marl at a colliery near Harecastle railway station.

Crustacea.

Beyrichia fastigiata (Jones and Kirby): rare: in a thin band of ironstone, Ipstones.—B. arcuata (Bean.): common: Upper Measures; Knowles, Chalky, Deep mine, and other ironstones, Longton; Adderley Green; Lower Measures, Cheadle coalfield.—Cythera Rankiniana (Jones and Kirby, Mon. Carb. Entom. pl. 2, fig. 24—27): rare: in a band of freshwater limestone, near Newcastle railway station.—C. (Carbonia) fabulina (Jones and Kirby): common: a large variety in the Knowles ironstone, Fenton; Cockshead ironstone; Hard mine coal shale, Adderley Green.

Cypridina radiata (Jones and Kirby): rare: Longton, Fenton. (Note.—In addition to the above species there are other forms not yet determined).

Eurypterus (Anthropleura) ferox (Quar. Jour. Geol. Soc., vol. xix., p. 84, fig. 8): one specimen of this rare form, from a bed of grey marl from a colliery near Harecastle Railway Station.

Belinurus trilobitoides (König. Bridg. Treatise): rare: one specimen in a nodule of clay-ironstone, Hard mine coal roof, Adderley Green.

Anthrapalæmon Grossarti (Salter, H. Woodward, Trans. Geol. Soc. Glasgow, vol. ii., pl. 3, fig. 5): in a thin band of ironstone, Ipstones.

Pisces.—The North Staffordshire coal-field has long been celebrated for yielding an abundance of rare fossil fishes. As far back as the year 1835, Sir Philip Egerton communicated to the Geological Society of London (Proc. Geol. Soc., 1835) the discovery of numerous remains of fossil fishes in the coal shales of Silverdale. These consisted of bones, teeth, and scales of fishes which furnished Professor Agassiz with specimens for the illustration of his great work "Recherches sur les Poissons Fossiles." Subsequently, Mr. Garner, in his "Natural History of Staffordshire," mentions several species in addition to those previously discovered.

The fish remains of these coal measures are of an interesting character, not only as regards their variety, but on account of the excellent state of preservation in which many of them are found. A large number of species new

to science, and also many rare species, have been found since the publication of Agassiz's work. Although perfect specimens are not uncommon, by far the largest number occur in a fragmentary condition, which renders the determination of their specific peculiarities a task of some difficulty. Enough, however, is left to enable us to learn much of the structure of the ancient Carboniferous fishes. In several of the ironstone shales, particularly that of the Deep mine and Knowles, they frequently occur in a fine state of preservation. These fishes must have died upon the spot where their remains are now found, and before putrefaction commenced have been buried in the mud or sediment now converted into shale. The fragmentary ones could not have been so rapidly buried, but after death were exposed to the action of the water, which scattered their remains. It may be, too, that after death they were subjected to the ravages of the numerous crustacea which abounded in the waters of that period, and which no doubt acted as scavengers in keeping in check the accumulation of decayed animal and vegetable matter: they would devour the softer portions, and leave the bones and scales to be scattered about. The fish remains are not confined to the shales, but are frequently found in the ironstones, especially in those of a nodular character.

In the New ironstone measures there is a remarkable bone-bed varying in thickness from half an inch to two inches or more. This bed is entirely made up of fish remains, broken fin-spines, teeth, coprolites, scales, and other parts, which are indiscriminately mixed together. It would appear that during the deposition of this bed, the waters swarmed with animal life. After death, these creatures could not have been rapidly entombed, but must long have remained exposed. How or by what means they

met with their death, whether by the introduction of some noxious matter, or by some sudden catastrophe, we know not, but the destruction of such an abundance of life as is contained in this thin stratum must have been effected by a cause of no ordinary description.

Many of the genera and species found in these coal-measures have a wide vertical range. Perhaps the most common and widely-distributed genera are Megalichthys, Cœlacanthus, Rhizodopsis, Diplodus, and Palæoniscus. These genera occur in the uppermost beds and pass through the whole series down to the lowest beds. Others again have a restricted range, *e. g.*, Cycloptychius and Mesolepis. The former has only been found in the Deep mine ironstone shale.

Of the four divisions or orders into which Agassiz divided the class Pisces, viz., the Placoid, Ganoid, Ctenoid, and Cycloid—divisions founded upon the form of the scales—the Placoid and Ganoid are the only orders found fossil in the coal-measures.

Of the Placoid order, about sixteen genera and more than thirty species have been found in North Staffordshire. The modern representatives of this order are the sharks and rays, fishes for the most part covered with thick skin, which in some members of the ray family is dotted with tuberculated plates, or small bony points, such as are found in the shagreen of the shark. The head is composed of a single cartilaginous box, and is never found in a fossil state. A very large portion of the extinct Placoids are allied to Cestracion—the Port Jackson shark.

Many living Placoids have strong bony spines which

stand up in front of the dorsal fins. Some of these are smooth, as those of the dog-fish (Spinax Acanthias): others have the lateral edges of the spine serrated (as Myliobates): many of them are of a formidable character, and all of them are calculated to enable their possessors to defend themselves against the attacks of an assailant.

The Placoids of the ancient Carboniferous seas must, judging from the remains found, have attained a large size. Like their modern representatives they too were armed with spines which far exceeded in size those borne by fishes of the present day. The teeth of these ancient fishes were of a character no less formidable, some of them being suitable for crushing and others for piercing and cutting. Owing to the cartilaginous nature of the skeleton, it is only teeth and fin-defences which are usually found in a fossil state. The spines were placed upon the dorsal margin of the fish to which the membrane of the fin was attached. They present many varieties of form as well as of surface ornament. One fish (Orthacanthus) had a long cylindrical spine eighteen inches or more in length, its under side armed with a double row of thorn-like barbs. Others had large bony spines ribbed longitudinally (as Ctenacanthus), or elegantly ornamented by lines arranged in a sort of zig-zag fashion (as Gyracanthus). The ends of many of these spines are frequently found rounded and worn. The inference to be deduced from this is, that these fishes frequented the more rocky parts of the sea, the ends becoming worn by rubbing against the rocks.*

At the present time many of these remains are enshrouded in mystery. Our knowledge of the relationship of the spines

* Quar. Jour. Geol. Soc., vol. ix., p. 281.

and teeth found in the same strata is exceedingly limited. "The mere discovery of teeth and spines in the same strata cannot be relied upon as evidence of their relationship. The only evidence of any value is the discovery of the conjunction of teeth and spines in one and the same individual."* Recent discoveries show that Helodus and Pleurodus, genera not uncommon in the sub-Carboniferous Limestone, had spines on their dorsal surface which have been found *in situ* in conjunction with the teeth. Ctenacanthus has also been found both in this coal-field and in the Scotch coal-measures in conjunction with teeth which were previously known as a distinct species allied to the genus Cladodus. These discoveries are of great importance, as they tend to lessen the already long list of species, many of which no doubt have been founded on insufficient data.

A considerable amount of investigation must still be made before a more comprehensive list can be given of the Plagiostomous fishes which have been found in this coal-field. No class of fishes occurs in such a condition so fragmentary, and none is more difficult to study than this. The following list will be found to contain the whole of the genera and species of this order which up to the present time have been recognized. When, however, any additional species have been identified a further enumeration will be given to supplement the existing list.

The Ganoid order, so called from the bright enamelled surface of their dermal covering, is represented in this coal-field by about twenty genera and upwards of thirty species. Fishes of this order differ from those of the Placoid order by having the body encased in a strong covering of thick bony scales, of which, amongst existing Ganoids, the

* Quar. Jour. Geol. Soc., vol. ix., p. 281.

Lepidosteus (Gar-pike) is a typical example. The living Ganoids are, in addition to Lepidosteus, Amia, Accipensor (Sturgeon), and three or four others, some of which are found in the North American waters. The first-named has the body encased with bony scales covered with a dense coating of enamel. Another has large scales along the back and sides, as the sturgeon. The extinct Ganoids had their bodies covered with a strong armature of solid bone. The head was protected by plates of great apparent strength (as was the Megalichthys). The jaws were filled with teeth of various sizes. The tail in these ancient fishes is heterocercal, or unequally lobed, the inequality being caused by the vertebral column being prolonged into the upper half of the fin, a peculiarity which prevailed amongst all the fishes of the older formations. The scales in many of the Ganoids are beautifully sculptured. Some of them are covered with fine wavy striæ and tuberculated head bones (as Cœlacanthus). Some have scales covered with fine lines arranged in various patterns (as Palæoniscus and allied genera); while in others (as Megalichthys) the external surface of the scales is covered with closely-set minute punctures.

With a view of assisting those members of the club who may be desirous of studying the fossil fishes of our coal-measures, we shall in the following pages give a brief description of the most prominent features exhibited in each species. This, together with a plate containing figures of the most characteristic specimens, will, it is hoped, be of service to the members and stimulate them to search for such specimens as may be obtained in the various localities in which they reside.

ORDER PLAGIOSTOMI (PLACOIDEI, AGASSIZ).
FAMILY CESTRACIONTIDÆ, AGASSIZ.

GENUS CTENACANTHUS, AGASSIZ.

Ctenacanthus hybodoides, Egerton. (Ref., Quar. Jour. Geol. Soc., vol. ix., pl. 12). The defensive spine known by this name is about ten inches in length, including about two inches of the base, which was inserted in the integuments. The greatest width is about one-and-a-half inch. "On quitting the body of the fish this spine is nearly straight for about half its length: it is thence slightly re-curved. The angle it forms with the line defining the integumentary investment is about 45°." The exposed portion of the spine is ornamented with parallel, longitudinal, rounded ribs. In several of our specimens there are twenty of these ribs near the base, diminishing to about ten at the apex.

Associated with Ctenacanthus we have found teeth which are closely allied to the genus Cladodus (see plate, fig. 15). The base of the tooth is narrow, and slightly concave from above, downwards: from the superior surface there spring five or more denticles. The principal denticle is near the centre of the tooth and is the largest. The secondary denticles are arranged on each side of the central cone. Sometimes there are two on each side; in others, there are three on one side and one on the other. The secondary denticles all decrease in size as they recede outwards from the principal cone. The denticles are pointed, and the the surface striated with coarse thread-like striæ running from base to apex. Numerous dermal processes have been found associated with these remains. These, as also teeth, are similar to those discovered with Ctenacanthus by Mr. Thomson in the Airdrie coal-measures. (Trans. Geol. Soc. Glasgow, vol. iv.)

Position and locality :—Rag mine, Knowles and Chalky mine ironstone, Fenton and Longton ; Brown mine ironstone, Silverdale.

Genus Gyracanthus, Agassiz.

Gyracanthus formosus, Agassiz (Ref., Poiss. Foss., vol. iii., tab. 5, fig. 4—8).—(See plate, fig. 3.)—Fine specimens of this defensive spine are not unfrequently found in these coal-measures. Our largest specimen is about fourteen inches in length, including about two inches of the base, which was inserted in the flesh. It gradually tapers from base to apex and is slightly bent. On the under side of the spine there is a deep cavity which extends from the base to about two-thirds of the entire length. The external surface is ornamented with ridges arranged in a zig-zag style, which cross the sides of the spine obliquely and again unite on the anterior margin. We have two varieties of this species, one of which is smaller, more compressed, and the point smooth and more rounded than the other. This is supposed to have been a dorsal spine ; the other is supposed to have been a pectoral spine. It is remarkable that nearly all these spines have their points worn away at the side opposite to that by which they were attached. The rubbing down of the points favours the idea expressed by Sir Philip Egerton, that Ctenacanthus and Gyracanthus were fishes that lived close to the more rocky parts of the ocean, the spines being worn by rubbing against the rocks. One or two large, flat, triangular bones have been found with the spines, which are supposed to have been carpal bones. No specimen has yet been found indicating the dentition of Gyracanthus.

Position and locality :—Not rare in the Rag mine and Knowles ironstones ; fine specimens in the Ash coal shale,

Longton ; Brown mine, Silverdale ; Cheadle coalfield.

Gyracanthus tuberculatus, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 1, fig. 1—7).—This species is very rare. In form it differs but slightly from G. formosus. It is, however, distinguished from it by the ornamentation. Instead of the ridges being zig-zagged, they are broken into elongated tubercles which impart to the surface of the spine a rasp-like appearance. Agassiz, in his description of this species, suggests that it might have belonged to the anterior dorsal and the preceding species to the posterior dorsal fin.

Position and locality :—Knowles ironstone, Fenton.

Genus Orthacanthus, Agassiz.

Orthacanthus cylindricus, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 45).—This is one of the rarest fin-defences found in these coal-measures. Specimens have been found eighteen inches or more in length. It is straight, circular in section, and the base is hollow and generally filled with a white powder. The surface of the spine is finely striated longitudinally. The posterior or under side of the spine is armed with a double row of closely-approximated thorn-like spines, hooked downwards and extending from the point to nearly half the length of the spine.

Position and locality :—Rag mine, Chalky mine, Knowles and Deep mine ironstones, Fenton and Longton ; Brown mine ironstone, Silverdale.

Orthacanthus, sp.—Our collection contains two fragments of a spine which differs in several respects from the preceding species. The spine is slightly bent ; a shallow cavity runs

along the posterior face, but its extent is not shown in our specimens. Along the margins of the cavity there are a number of blunt, elongated tubercles. The surface of the spine is thickly strewn with fine punctures.

Position and locality:—Rag mine ironstone, Fenton.

Genus Ctenoptychius, Agassiz.

Ctenoptychius apicalis, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 19, fig. 1A). (Harpacodus apicalis, Ag. MSS., June 27, 1859). (See plate, fig. 12).—This species was named by Agassiz from specimens collected at Silverdale. The crown of the tooth is transversely oval, the upper edge semi-elliptically rounded and divided into eight or more acutely-pointed vertical lobes; the central lobe is the highest, those on each side gradually diminishing in size as they proceed to the exterior. The inner surface of the crown is smooth, and apparently concave. This appearance arises from the imbricating fold which projects beyond the root of the crown, and which divides the root from the base. This fold is slightly arched downwards and apparently double. What renders some of these teeth so remarkable is, that on the inner surface of the tooth, the fold which divides the base from the crown bears upon the border a row of acutely-pointed denticles: behind this, and standing above it, there is a second row: each contains about eighteen denticles unequal in size. This form of tooth is rare and probably belonged to the front of the mouth. The base of the tooth is broader than the crown and equal in height. We have several specimens of teeth which differ from those figured by Agassiz. These, probably, only differ according to the position they occupied in the mouth.

Position and locality :—Not rare in the Rag mine, Fenton, and Brown mine ironstone, Silverdale ; more rare in the Knowles, Chalky, and Deep mine ironstones, Fenton and Longton.

Ctenoptychius denticulatus, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 19, fig. 5—7.)—This species is not uncommon in the Deep mine ironstone at Longton. The crown of the tooth is plate-like, swollen on the exterior surface, the internal concave. The margin of the crown is denticulated with parallel denticles nearly equal in size, and rounded. We have several specimens in which the tooth-plate is much elongated, and has upwards of twenty-six denticles. The base of the tooth is nearly double the height of the crown: it contracts gently below the denticulated margin ; the lower portion is produced into fang-like processes, from three to seven in number, according to the breadth of the tooth.

Position and locality :—Deep mine and Rag mine ironstones, Fenton and Longton.

Ctenoptychius pectinatus, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 19, fig. 2—4).—This tooth is moderately common in the Rag mine ironstone. The crown of the tooth is arched transversely, and the upper margin denticulated. The internal surface of the crown is concave, the external surface convex ; a deep constriction separates the crown from the base. The base is contracted below the denticulated margin, and the lower portion, as in the preceding species, is produced in four or more fang-like processes.

Position and locality :—Deep mine and Rag mine ironstones, Fenton and Longton.

Ctenoptychius unilateralis, Barkas. (Ref., Geol. Mag., vol. vii., p. 43.)—Several specimens of this little-known fossil have been found at Longton. It is a question yet undecided, whether this is a tooth or a jaw.

Position and locality :—Deep mine, Knowles and Chalky mine ironstones, Fenton and Longton.

Genus Helodus, Agassiz.

Helodus simplex, Agassiz. (Ref., Poiss. Foss., vol. iii., tab. 19, fig. 5—7.)—The peculiar teeth to which Agassiz assigned the title of H. simplex were found in the coal shales of Silverdale. Until within a few years, teeth were all that was known of this fish. About four years ago we discovered in the Knowles ironstone, at Fenton, the remains of an almost entire specimen of Helodus, showing the teeth, a portion of the body, and a small spine. Fragments have since been found exhibiting portions previously unknown. We propose briefly to notice the most characteristic features as shown by the fragments in our collection, reserving for a future occasion a more detailed description. In none of our specimens is the contour of the body shown, nor can the size of the fish be accurately determined. Judging from a number of specimens, the maximum length was about twelve inches. Shagreen covers the whole of the body; traces of dermal tubercles can be seen scattered on different portions of the fish, but in no instance is their form clearly defined. At a point, probably midway between the anterior and posterior extremities of the fish, there is a small spine. It projects from the dorsal margin and is slightly inclined backwards, apparently in its natural position. In one specimen a small portion of the dorsal fin is preserved; portions of several of the other fins are also preserved. In

one fragment there are impressions of several small, delicate, interspinous bones or fin-supports, but in none of the specimens is the caudal fin preserved. The spine is about an inch and a-half long, including the portion inserted in the flesh, and about a quarter of an inch wide at the base ; it gradually tapers to a rather blunt point. The lateral edges of the spine are straight and compressed, the centre slightly swollen, the surface marked with numerous short, shallow, longitudinal grooves, which cover nearly two-thirds of the entire length ; the remaining portion is smooth. No portion of the head is preserved. It was probably cartilaginous throughout. Within its area, numerous teeth are shown ; in one specimen more than forty of the teeth are preserved. The teeth (see plate, fig. 11) agree with the type specimens figured by Agassiz (fig. 5—7, *op. cit.*) According to that authority, the teeth "have a base small in proportion to their height, the crown rising from the base in the form of a cone and very obtuse." The root is short and nearly as broad as the crown, and is covered with shallow cavities ; the surface of the crown is smooth and generally of a dusky white enamel and finely punctated. At present, very little is known of the arrangement of the dental apparatus of Helodus. A specimen in our collection shows a section of the mouth in which teeth of the form above described are shown *in situ*. They appear to be arranged in rows in both the upper and lower part. They probably formed a pavement-like dentition covering the whole of the floor of both halves of the mouth, the undulating surface of the upper half fitting exactly into that of the lower half. Our collection contains many teeth which differ from the typical specimen. It is probable that of these there are some which are not specifically distinct, but were adapted to particular parts of the mouth. It is impossible to determine the relationship of these various forms until

more complete specimens showing the whole of the dental series have been found.

Position and locality :—Deep mine, Knowles, and Chalky mine ironstones, Fenton and Longton ; Gubbin ironstone, Hanley ; Brown mine, Silverdale ; Ash coal shale, Fenton.

Genus Janassa, Munster.

Janassa linguæformis, Atthy.—(Climaxodus linguæformis, Hancock and Atthy), (Ref., Ann. Nat. Hist., series 4, vol. ii., p. 321).—A single tooth of this rare genus has occurred at Longton. The length is greater than the width, and the tooth tapers behind. The front has a wide scoop-like margin ; behind this, the surface is covered with imbricated, transverse ridges, which form the grinding edge of the tooth. (See plate, fig. 8.)

Position and locality :—Deep mine ironstone, Longton.

Genus Pleurodus, Agassiz.

Pleurodus Rankinii, Ag. (Ref., Poiss. Foss., vol. iii., p. 174.)—Single teeth of this species are not unfrequently found in the Hard mine coal shale. The teeth are somewhat boss-like in form, "elongated and ridged or carinated along the longer axis : the sides are considerably expanded in the centre, the expansions dying out towards the centre of the tooth. Usually the expansion is more produced on one side than on the other, and the ridges inclined to the opposite side." * A specimen has recently been found in the Northumberland coal-measures showing

* Annals of Nat. Hist., vol. for 1872.

a considerable portion of the body. A short, strong spine, marked with coarse longitudinal ridges, projects from the dorsal surface. The body is covered with shagreen, dermal-tubercles occurring in large patches on various portions of the fish. The jaws are somewhat of the shape of a horse-shoe. Three teeth, each of different forms, are arranged on each side the jaw. †

Position and locality :—Hard mine coal shale, Adderley Green ; Knowles ironstone, Fenton.

Pleurodus affinis, Agassiz. (Ref., Poiss. Foss., vol. iii., p. 174.)—Detached teeth, which we refer to this species, have been found in the same beds as the preceding species. Probably the two forms are not specifically distinct.

Position and locality :—Hard mine coal shale, Adderley Green ; Knowles ironstone, Fenton.

Genus Pœcilodus, Agassiz.

This genus is very rare in these coal-measures. The most prominent characteristic of teeth of this genus is the longitudinal step-like ridges which cross the surface of the tooth. Two or three imperfect specimens of an unrecognized species have been found at Longton.

Position and locality :—Roof of Bay coal, Longton.

† Monthly Review of Dental Surgery, 1874.

Family Trygonidæ.

Genus Pleuracanthus, Agassiz.

Pleuracanthus (Diplodus) gibbosus. (Ref., Poiss. Foss., vol. iii., tab. 22, fig. 1—5.)—The generic title of Diplodus was given by Agassiz to some curious teeth which were discovered in 1834 in the coal shales of Silverdale. Two species were named by Agassiz, D. gibbosus and D. minutus, the former from Silverdale the latter from Burdie House. Since the publication of Agassiz's description, specimens have been found which prove that the teeth of Diplodus belong to the same fish as the fin-spine named by Agassiz Pleuracanthus. (See Ann. Nat. Hist., vol. xx., series 2.) Professor Kner has recently given a detailed description of a remarkable fish called Zenacanthus (Orthacanthus) Dechenii, a fish possessing teeth and a spine which do not differ generically from Diplodus and Pleuracanthus. (See Geol. Mag., vol. i., p. 376.) The teeth of P. gibbosus have a round base from which spring two lateral and one small central denticle of unequal length. The longest of these denticles is more divergent and more bent than than the rest. It is sometimes on the right side and sometimes on the left, according to the place it occupied in the mouth. The next in size is straighter, and slightly narrower at the base. The lateral edges of both denticles are often finely serrated. The smallest denticle is placed between the larger ones at the basal junction, and is scarcely half the length of the lateral denticles. In front of this there is a large tubercle. (See plate, fig. 9). We have specimens which differ from the above. One of these has a narrow base from which spring two straight narrow lateral denticles divergent at the same angle. Between these, there are two small, slender, denticles. There are several other teeth, all of which differ

in form from the typical specimen. It is probable that in Pleuracanthus, as in existing sharks, there were teeth of various sizes and forms, adapted to particular parts of the mouth. The fortunate discovery of a specimen showing the whole of the dental series would enable us to determine the relationship of these various forms. Doubt has been expressed whether Diplodus Ag. is a tooth or a dermal tubercle. Our own observations convince us that it is a tooth. We have specimens showing patches of a granular cartilaginous material, with a large number of teeth apparently placed in rows in a part which no doubt was once occupied by the head.

Position and locality :—Teeth are very common, especially in the Rag mine and Deep mine ironstone shales, Fenton. They are not uncommon in the Brown mine, Silverdale. Fine specimens have been found in the Gubbin ironstone, Shelton.

Pleuracanthus (Diplodus) minutus. (Ref., Poiss. Foss., vol. iii., tab. 22B, fig. 6—8.)—This species is said to differ from D. gibbosus by its small size. The lateral denticles are slightly bent below and more arched at the summit, and are longer in proportion to the size than in D. gibbosus. No mention is made of the central denticle. The figure given by Agassiz is too indistinct to enable us to make out the number with certainty. There appear to be two denticles in the centre. We have several specimens so distinguished. It is probable that this species is not distinct from the last-named.

Position and locality :—Rag mine ironstone, Fenton.

Pleuracanthus lævissimus, Agassiz. (Ref., Poiss. Foss.,

vol. iii., tab. 45, fig. 4—6.)—A few specimens of this formidable fin-spine have been found in various parts of the coalfield. The largest of these is about six inches in length, rather flat at the base, but rounder towards the point. For about half its length the lateral margins are armed with fine spine-like teeth, pointed downwards. Along the basal portion of the spine there is a round, deep groove.

Position and locality :—Deep mine, Rag mine, and Chalky mine ironstones, Fenton and Longton ; Brown mine, Silverdale and Kidsgrove ; Gubbin ironstone, Shelton.

Pleuracanthus n. sp.—Our collection contains several small spines which are specifically distinct from P. lævissimus. The spine is about two-and-a-half inches in length, and nearly circular in section. The lateral margins are armed with seven or eight spines crowded together near the summit.

Position and locality :—Deep mine and Chalky mine ironstones, Longton.

Order Ganoidei.

Family Sauroidei, Agassiz.

Genus Acrolepis, Agassiz. (Ref., Poiss Foss., vol. ii., p. 79.)

Detached scales, which we refer to this rare genus, have occurred in several of the ironstones. The scales are thick and rhomboidal or lozenge-shaped. The upper portion is marked with thick, rounded, anastomosing ridges in the direction of the longer axis.

Position and locality :—Cockshead ironstone, Adderley Green ; Knowles ironstone, Fenton.

Genus Pygopterus, Agassiz. (Ref., Poiss. Foss., vol. ii., p. 74.)

Three distinct species of Pygopteri occur in the Pottery coalfield. The most common species is one which ranges from five inches to nearly two feet in length. The scales are lozenge-shaped : the upper surface is ornamented with well-defined ridges on the posterior margin ; the anterior margin is minutely punctured. A full description of the structure and peculiarities of these species will shortly appear.

Position and locality :—Knowles and Deep mine iron-stones, Fenton and Longton.

Family, Saurodipterini, Huxley.

Genus Megalichthys, Agassiz.

Megalichthys Hibberti, Agassiz. (Ref., Poiss. Foss., vol. ii., tab. 63—64.)—This is one of the most abundant and widely distributed of the fishes found in these coal-measures. There are few fossiliferous beds that do not contain fragments of this interesting fish. Although not rare, it generally occurs in a fragmentary condition, only one or two nearly entire specimens have been found. The average length of Megalichthys is about five feet ; fragments which must have belonged to fishes of this size have been collected in various parts of the coalfield. The body of the fish is covered with quadrangular scales (see plate, fig. 14), which cross the body obliquely and over-lap each other. The posterior or

over-lapping portion of the scales is thinner than the anterior. This, when *in situ,* gives them one uniform strength and smoothness. The posterior and superior margins of the scale have a deep groove into which a corresponding ridge in the margin of the over-lapping scale fits. Little or nothing is known of the fins of Megalichthys. A specimen in our collection has the pectoral fins well preserved. They are lobate, *i. e.,* the central portion of the fin is covered with scales, the fin rays forming a fringe round the lobe. A fine specimen from the Gubbin ironstone, at Shelton, presented by Mr. Garner to the Museum of Practical Geology, shows the caudal fin in a fine state of preservation.

The head (as shown by a perfect example in the author's collection) was protected by bony plates of great apparent strength. The snout is formed by a curved bone. The orbits are small, circular cavities, placed high and forwards: one is well shown in our specimen. On the under side of the head there are two jugular plates; along their margins there are a number of lateral jugular plates. Both scales and head bones are covered with a strong coating of ganoine, and are ornamented with close-set minute punctures. The teeth of Megalichthys are of two kinds: those in the outer dentary margin of the maxilla and premaxilla are small and smooth. Behind these there are larger teeth covered with fine parallel striæ. The mandibular teeth are large, conical, smooth teeth, with short, deep, longitudinal depressions at the base (see plate, fig. 10). The outer dentary margin is set with small conical, smooth, close-set teeth. Of the endoskeleton of Megalichthys, good specimens of vertebræ are frequently found. They are small osseous rings, generally found separated. Occasionally we find a number of them united with the ossified neural arches *in situ.*

Position and locality:—Common in all parts of the coal-field.

Megalichthys coccolepis, Young and Thomson. (Ref., Brit. Assoc. Report, 1869, p. 102.)—Fragments of the head bones and a few detached scales of this new species have been found. The scales are rhomboidal, and both they and the head bones have the upper surface covered with small round tubercles.

Position and locality:—Cockshead ironstone, Adderley Green; Wood's mine coal shale, Longton; very rare.

Megalichthys rugosus, Young and Thomson. (Ref., Brit. Assoc. Report, 1869, p. 102.)—Several small jaws, containing teeth finely striated; also scales covered with fine, confluent tubercles, which we refer to this species, have been found.

Position and locality:—Knowles and Deep mine ironstones, Fenton.

Genus Centrodus, M'Coy. (Ref., Ann. Nat. Hist., 1848.)

The characteristic features of teeth of this genus, as defined by M'Coy, are, that they are "conical, slightly curved, apex-pointed, circular in section, and very finely striated longitudinally." We have several specimens which possess the above characteristics. No scales or bones have been found with the teeth, which may eventually turn out to be only a variety of Megalichthys.

Position and locality:—Rag mine and Deep mine ironstones, Fenton and Longton.

Genus Rhomboptychius, Huxley. (Ref., Quar. Jour. Geol. Soc., vol. xxii., p. 604.)

This genus was established from specimens collected in this coal-field. According to Dr. Young *(op. cit.)* "the scales vary from cordate-ovate to rhombic; the length in the former case exceeds the breadth: in the latter the reverse holds. In both forms the punctate free surface is ornamented with coarse straight ridges which follow the outline of the sides, meeting at an angle posteriorly, and thus giving a rhombic aspect to the scale." Our collection contains several fine examples of the cranial shield. They are solid: the parts are united by well-marked sutures. The inner posterior orbital border is preserved, but not the outer border. One of these specimens exhibits the upper surface of the cranium, which is ornamented with coarse tubercles. There are others in which the ornamentation consists of fine rounded ridges more or less confluent, the surface of the bone being finely reticulated, the jugular plates and opercular being similarly ornamented. The specimens hitherto discovered are too fragmentary to enable us to determine whether these and other differences are of specific importance. One or two fragments of mandibles have occurred. One of these, in our collection, shows that this bone was of great strength. Both ends of the jaw are imperfect, but the general arrangement of the teeth is similar to that in the same bone in Megalichthys, to which genus this fish is closely allied. In our specimen, one large and perfect tooth and the base of a second tooth are shown. The large tooth is straight and plicate at the base: about the middle of the tooth there are two rings of short, longitudinal depressions. The outer dentary margin is set with small, conical teeth. Many large vertebræ of Rhomboptychius have been found: they are thin osseous rings, some of them an inch and a half in diameter.

Position and locality :—Deep mine, Knowles, and Chalky mine ironstones, Fenton and Longton.

Genus Rhizodopsis, Huxley.

Rhizodopsis sauroides, Huxley.—*Holoptychius sauroides,* Agassiz. (Ref., Quar. Jour. Geol. Soc., vol. xxii., p. 59—60.) —This species is not rare, and is widely distributed. Many fine specimens have been found in the Knowles ironstone. The length of the fish ranges from three inches to eighteen inches or more. The body tapers posteriorly. The greatest depth is immediately behind the pectoral arch. The body of the fish is covered with orbicular-shaped scales, which cross the body obliquely. The upper surface is ornamented with fine, concentric radiating striæ. The head is much flattened and the gape is wide. The maxilla is filled with fine, conical teeth. The mandible is straight, broad at the symphysis, and contains teeth of two sizes ; the largest, four in number, long and sharp, slightly incurved. The outer margin is set with small, strong, conical teeth. There are two jugular plates, but no lateral plates. These are ornamented like the operculars with fine, parallel ridges. The pectoral fins are well shown in many of our specimens. In a specimen ten inches in length, the pectoral fins measure two and a half inches in length, and one and a half inch in breadth. They are acutely lobate, with rounded margins. The central stem in each fin is covered with scales. The most complete specimens occur in ironstone nodules. In these, the osseous rings composing the vertebral column are frequently preserved *in situ.* Our collection contains several small specimens of about four inches in length. The scales are much thinner than in those of the larger individuals. At present, it is not clear whether or not they are specifically distinct from the larger specimens.

Position and locality :—Not rare in the Knowles ironstone, Brown mine, and generally throughout the coal-field.

GENUS STREPSODUS, HUXLEY.

Strepsodus sauroides, Huxley. (Ref., Quar. Jour. Geol. Soc., vol. xxii.)—A tooth of this species is figured in the Transactions of the Tyneside Naturalists' Field Club as Holoptychius sauroides (vol. vi., pl. vi., fig. 6), a species established by Agassiz and mentioned by him in his "Tableau Général" but not described. Teeth of this species are not rare in these coal-measures. They are generally found detached. In the author's collection there are two fragments of a right and left ramus of the mandible. One of these fragments is two and a half inches long. Its exterior surface near the alveolar border is covered with small tubercles. The remaining portion is of a reticulated pattern. A large tooth, one and a quarter inch long, is placed at the symphis: five smaller teeth, each seven-sixteenths of an inch in length, are placed at a distance of about a quarter of an inch from each other. The teeth are laterally compressed at the base, but become more circular in the shaft. They are recurved "and twice bent near the apex," and are covered with fine longitudinal striæ, which in some cases cover the whole of the surfaces. Generally the striation is confined to the convexity of the shaft and the lateral surfaces. We have specimens perfectly smooth. It remains to be seen whether this peculiarity is of specific importance.

Position and locality :—Not rare in the Rag mine and Deep mine ironstones, Fenton and Longton ; Knowles ironstone, Fenton ; Brown mine, Silverdale ; Gubbin ironstone, Shelton.

Genus Dendroptychius, Huxley. (Ref., Quar. Jour. Geol. Soc., vol. xxii., p. 601.)

We have a number of head bones, scales, and other parts which we refer to this genus. There are many points requiring further elucidation before the distinctive characteristics of this genus, as given by Dr. Young *(op. cit.)*, can be finally established.

Position and locality:—Deep mine ironstone, Longton.

Genus Diplopterus, Agassiz.

Diplopterus carbonarius, Agassiz. (Ref., Poiss. Foss., vol. ii., p. 162.)—Scales and head bones of a fish which we refer to this species have occurred at Norton and Adderley Green. They are small rhomboidal scales covered with ganoine. The surface is finely punctured. We are inclined to think that this species was founded from imperfect materials, and that in reality it is only the young of Megalichthys.

Position and locality:—Hard mine coal shale, Adderley Green, Norton.

Family Glyptodipterini, Huxley.

Genus Holoptychius, Agassiz (Rhizodus, Owen.)

Rhizodus (Holoptychius) Garneri, Murchison.—This species is mentioned by Agassiz in his "Tableau Général," but has not been described. It was discovered by Mr. Garner at Kidsgrove, and was named after him. The type specimen is lost, but the scale figured (see plate, fig. 4) is believed

to be identical with the original specimen. The scales are rotundo-quadrate, the anterior portion ornamented with fine, concentric striæ, the posterior or free surface covered with broad, broken undulations which appear like tubercles. Near the centre of the scale there is a small raised tubercle or boss. Doubt has been expressed whether this boss is on the upper or under side of the scale. Dr. Young (Quar. Jour. Geol. Soc., vol. xxii., p. 600) affirms that it is on the under side. Roemer, * on the contrary, describes it as being on the upper surface.

Position and locality:—Brown mine, Kidsgrove; Deep mine, Knowles, and Chalky mine ironstones, Longton and Fenton.

Family Mesolepidæ, Young.

Genus Mesolepis, Young.

Mesolepis Wardi, J. Young, M.D. (Ref., Quar. Jour. Geol. Soc., vol. xxii.)—The genus Mesolepis is at present restricted to this coalfield. The body in M. Wardi is of an ovate form and covered with oblong scales, rather broad in proportion to their height. In the dorsal and ventral halves they appear to be shorter than in the middle of the body. The upper surface of the scales is ornamented with short, vertical ridges. The caudal root is long and much broader than in Platysomus. In none of our specimens are the bones of the head sufficiently preserved to enable us to distinguish the component parts. In one or two specimens, however, the teeth are well shown. These, according to Dr. Young *(op. cit.)*, are very similar to those in Platysomus macrurus, "presenting a bluntly conical minie-bullet-shaped

* Zeitschr Deutsch Geol. Gesellsch, p. 272, 1865.

crown, with a constricted neck much like the Globulodus of Munster."

Position and locality :—Knowles ironstone, Fenton.

Mesolepis scalaris, J. Young, M.D. (Ref., Quart. Jour. Geol. Soc., vol. xxii., p. 313.)—The body of this fish is more arched in the dorsal region than in the last species. The scales are similar in shape; the scale ornament is "arranged in close-set ridges over the middle two-thirds of the scale; above and below the ridges, irregular tubercles, and towards the posterior margins, sinuous tubercular lines." The peduncle of the tail is shorter than in M. Wardi, and the lobes of the tail are narrower and much more prolonged. The rarity of this and the other species, and the imperfect condition in which they usually occur, prevent a more detailed description of their character being given.

Position and locality :—Knowles ironstone, Fenton; Cockshead ironstone, Adderley Green.

Family Platysomidæ, Young.

Genus Platysomus, Agassiz.

Platysomus parvulus, Ag. (Ref., Quart. Jour. Geol. Soc., vol. xxii., p. 303.)—The genus Platysomus is common in the Knowles and Brown mine ironstones. P. parvulus is a small, flat fish about three and a half inches in length and two inches broad at the broadest part. The head is triangular, and about one-fourth of the length of the body. The body is covered with oblong scales, higher than they are broad, and ornamented with fine, parallel striæ: the crests are frequently crenelated. The mandible is a short,

slender bone, filled with fine, sharp teeth. The premaxilla and maxilla are small. The latter are in one piece and both are filled with minute sharp teeth. The dorsal fin commences at a point behind the dorsal ridge, and extends to the commencement of the upper lobe of the tail. The anal fin is of the same size and character as the dorsal. Professor Young, in his description of this fish,* says there is no evidence of the existence of a ventral fin. Later discoveries, however, have demonstrated the presence of this member. †

Position and locality:—Knowles ironstone, Fenton; Brown mine, Silverdale; Apedale.

Platysomus parvulus, var., J. Young, M.D. (Ref., Quart. Jour. Geol. Soc., vol. xxii., p. 303.)—This is a somewhat larger fish than the last species. The chief difference between this species and P. parvulus is the more oval shape of the body and the absence of the angular dorsal peak, so marked a feature in the above species. The scales are similar in shape. The striæ on the scales are finer and the crests smooth.

Position and locality:—Knowles ironstone, Fenton and Longton.

FAMILY AMPHICENTRIDÆ, YOUNG.

GENUS AMPHICENTRUM, YOUNG.

Amphicentrum granulosum, Young. (Ref., Quar. Jour. Geol. Soc., vol. xxii., pl. xx.)—The genus Amphicentrum

* Quar. Jour. Geol. Soc., vol. xxii., p. 305.

† Ann. and Mag. Nat. Hist., vol. for 1872, p. 253.

was founded on specimens collected in the Pottery coal-field. It is not rare in some localities. The species under notice is broad in proportion to its length. It varies in size, from an inch and a half to seven inches in length, and from one inch to six inches in breadth. At the dorsal and ventral margins the body of the fish is prolonged into points, the ends being tipped with a short, strong bone, curved at the point. The body is covered with scales "high in proportion to their breadth:" near the margins they are much shorter. The upper surface of the scales is ornamented with fine tubercles, which are more or less confluent. The dorsal and anal fins are composed of slender rays finely fringed at their extremities. The dorsal fin is an exact counterpart of the anal fin. In none of our specimens are the pectoral fins preserved, nor is their form known. A row of triangular fulcral scales covers the upper lobe of the caudal fin. The dentary apparatus of the fish is of a complicated character and difficult to describe Generally, however, the mandibles may be said to be composed of a strong triangular bone which bears on its margins six or seven conical tubercles, formed by the prolongation of the bony tissue of the jaw. The maxillaries differ somewhat from the mandibles: in both there is a similar style of tooth. For a detailed description of the jaws, together with their microscopical structure, we must refer our readers to Dr. Young's paper *(op. cit.)*

Position and locality: Knowles and Deep mine ironstones, Fenton and Longton; Brown mine, Silverdale; Ash coal shale, Longton.

FAMILY LEPIDOSTEI, AGASSIZ.

GENUS PALÆONISCUS, AGASSIZ.

This genus is the most abundant not only in species but in individuals of any genus of fishes found in these coal-measures. From the great number of remains found, it would appear that the ancient carboniferous seas swarmed with Palæonisci. No doubt they filled important offices in the then economy of nature, and served as food for many of the larger ganoids which co-existed with them. The Deep mine ironstone shale is especially rich in Palæonisci. The specimens are found on the surface of the laminæ. They invariably retain the beautiful enamelled surface of the original ganoine. Many of the examples which have been found present a lateral view, with the various fins outspread and in a good state of preservation. Examples with the body bent, the mouth extended to the uttermost stretch, and presenting an appearance as if the fish had died in agony are frequently found. Individuals showing the ventral aspect occasionally occur. In a short appendix to a report on "The Distribution of the Organic Remains of the North Staffordshire Coal-Field," * mention is made of the occurrence of P. Robisoni (Ag.), P. ornitissimus (Ag.), P. monensis (Eg.), and P. striolatus (Ag.) A careful comparison of these species with a large number of specimens both in our own as well as in other collections, convinces us that Dr. Young was in error in placing these species in the list of fishes of these coal-measures. Admitting, as we do, that the resemblance is strong between the above-named species and specimens of Palæonisci which have been collected, we think the specific distinction is such as to warrant their

* Brit. Asso. Report, vol. for 1865, p. 317.

removal from our list. By far the largest number of specimens found in the Deep mine belong to a single species. The remainder belong to four or five species which are probably new to science. The following species have been recognised :—

Palæoniscus Egertoni, Agassiz. (Ref., Brit. Organic Remains, Dec. vi., pl. 11.)—This is a small species not more than two and a half inches in length. The body is covered with rhomboidal scales, "characterised by being deeply furrowed and serrated at the posterior margin."

Position and locality :—Goldmine ironstone, Silverdale; Knowles ironstone, Fenton.

Palæoniscus Wardi, n. sp., J. Young, M.D.—The maximum length of this species is from three to four and a half inches; its maximum breadth about three quarters of an inch. The body continues of a similar width up to the dorsal and ventral fins: it then contracts to little more than one quarter of its width. The fins are of a moderate size, with the exception of the pectorals, which are very long: these consist of about twenty-four fine, slender rays. The ventrals are about half the length of the pectorals: they consist of from twelve to fourteen fine, delicate rays. The anal fin, in a specimen four inches in length, is two and a half inches from the snout. The number of fin rays is thirty-two. The dorsal fin is placed slightly in advance of the anal, and has the same number of jointed fin-rays. In none of our specimens is the caudal fin well shown. The head is one inch in length, and its breadth is the same as the greatest width of the body; the snout is blunt and rounded; the gape moderately large; the jaws are strong and filled with minute sharp-pointed teeth on their outer border, behind which there

are teeth of a larger size. The opercular plates are narrow, rounded behind, and covered with fine, radiating striæ. The branchiostegal rays are eight in number. The most distinctive character of this species is found in the scales. They are solid and of a rhomboidal form, and covered with short ridges or tubercles on the anterior and dorsal margins. On the posterior margin these ridges are longer and more strongly defined, and terminate into sharp cusps on the posterior or free margin. This style of ornamentation differs from that of any other species of Palæoniscus which we are acquainted with.

Position and locality :—Ash coal shale, Longton, Fenton.

GENUS CYCLOPTYCHIUS, HUXLEY.

Cycloptychius carbonarius, Huxley. (Ref., Brit. Ass. Report, vol. xxxv., p. 313, Geol. Mag., I. vol. Dec. 2.)—This beautiful genus was first discovered by Mr. Molyneux, F.G.S., in the Deep mine ironstone, Longton. The average length of the fish is from four to five inches; its greatest depth is at the shoulders: from this point the body gradually tapers towards the tail. The body is covered with thin scales, cycloidal anteriorally, more pointed posteriorally. * The free surface of the scales is ornamented with fine, raised ridges, running parallel with the margins of the scale. In some of them it is zig-zagged. On the back and belly the scales are much smaller than those on the sides of the fish. The head is broad and stout in proportion; the surface is ornamented with fine tubercles. The jaws are armed with slender, conical, sharp-pointed teeth of two sizes. The pectoral and ventral fins are small, the former with

* Professor Traquair describes the scales as rhomboidal.—Geol. Mag., vol. or 1874.

rounded terminations. The dorsal fin is large and triangular, the anal fin of the same size and placed directly opposite to the dorsal fin. The dorsal fin in this genus is much nearer the tail than in the genus Palæoniscus. In this respect, Cycloptychius resembles the genus Catopterus, Redf.

Position and locality:—Deep mine ironstone, Longton.

GENUS GYROLEPIS, AGASSIZ. (Ref., Poiss. Foss., vol. 2.)

This rare genus is represented in this coalfield by one species, and this occurs only in a very fragmentary condition. It is possible that these fragments belong to a species described by Agassiz (G. Rankinii).

Position and locality:—Knowles ironstone, Fenton; Cockshead ironstone, Adderley Green.

FAMILY ACANTHODEI, AGASSIZ.

GENUS ACANTHODES, AGASSIZ.

Acanthodes Wardi, Egerton. (Ref., Quar. Jour. Geol. Soc., vol. xxii., pl. xxiii.)—The genus Acanthodes is not uncommon in the Devonian formation, but it is exceedingly rare in the Carboniferous rocks. Only three species have hitherto been found in the latter. The average length of the species under notice is from eight to nine inches. Specimens of a larger size, which may represent a different species, have been found. The body of the fish is covered with small scales, smooth on their external surface, and covered with a thick coating of ganoine: near the head they decrease in size, and present a skin-like appearance: they increase in size in the caudal half of the fish. The pectoral, ventral,

and dorsal fins are each supported by spines. The pectoral spines are the longest: they are broad, flat, and scimitar-shaped, with flattened ends. Along the anterior margin of the spine there is a deep parallel groove. The remaining spines are similar in character but smaller. The contour of the head is not accurately defined in any of our specimens. Probably this portion of the fish was not sufficiently ossified to be preserved. The small, narrow, bony plates which encircled the orbits are frequently preserved. The upper surface is beautifully ornamented with fine tubercles. The small stiliform bones of the lower jaws are occasionally found, but no specimen showing the dentition of the fish has yet occurred.

Position and locality:—Deep mine ironstone, Longton; Brown mine ironstone, Silverdale; Knowles ironstone, Fenton; Moss and Ash coal shales, Longton.

Family Cœlacanthi, Agassiz.

Genus Cœlacanthus, Agassiz.

Cœlacanthus lepturus, Agassiz. (Ref., Ag. Poiss. Foss., vol. 2, Mem. Geol. Survey, Dec. 12.)—Many specimens of this curious fish, varying in length from two inches to nearly two feet, have been collected in this coal-field. Cœlacanthus had a wide range in time, being found in the lowest beds and passing through to the uppermost bed. The body of the fish is covered with thin cycloidal scales, the free surface being ornamented with narrow, nearly parallel ridges "which converge towards and meet along a line drawn through the centre and point of the scale." When *in situ*, this portion of the scale is alone visible. It has two dorsal fins, which, like the other fins, are supported by fine, long,

hollow rays. The caudal fin has a short terminal prolongation covered with scales. This curious appendage is rarely preserved. The contour of the head is not well shown in any of our specimens. The surface ornament of the head is of a granular character. It has two elongated jugular plates, beautifully ornamented with fine, undulating, nearly parallel ridges. The walls of the air bladder were ossified, and this part is frequently preserved in a fossil state.

Position and locality:—Not rare in the Deep mine ironstone; more rare in the Chalky mine, Knowles, and Brown mine ironstones; fine specimen in the Cheadle coal-field.

Family Ctenododipterini, Huxley.

Genus Ctenodus, Agassiz. (Ref., Poiss. Foss., vol. iii.)

The genus Ctenodus was established by Agassiz on a single specimen of a tooth which is now preserved in the Leeds Museum. Several species are enumerated by Agassiz, but only one species was described (C. cristatus). More recently * Mr. Atthey has described several new species from the Northumberland coal-shales. Much interest is attached to this genus in consequence of the discovery, a few years ago, of the extraordinary fish named Ceratodus Fosteri, a fish now living in several of the rivers of Australia, which is said to have teeth identical with those of the extinct genus Ceratodus from the Triassac rocks, and to be still more closely allied to the genus Ctenodus from the Carboniferous formation. The dental apparatus is said to

* Ann. Nat. Hist., ser. 4, vol. 1, p. 77.

consist of "two dental plates with a flat undulated and punctated surface, and with five or six sharp prongs on the outer side." It has two similar dental plates in the lower jaw. It is also described as having in the front part of the upper jaw "two obliquely-placed incisor-like dental lamellæ which have no corresponding teeth in the lower jaw." (See "Nature," 1871.) In the British Museum there are several specimens of Ctenodi, one of which shows a large portion of a skull with both the upper teeth and one lower tooth *in situ.* From a careful examination of these, as well as of a large number of specimens in our own collection, it would appear that the teeth of fishes of this genus vary much in individuals. No specimen has yet been described having the whole of the dental series complete, nor, so far as we know, has a specimen been found sufficiently perfect to enable us to determine whether or not Ctenodus was furnished with a tooth in the front part of the mouth. The close resemblance between this genus and its modern representative would lead us to infer that a similar additional tooth existed in the latter genus. This surmise, together with many other peculiarities, can only be satisfactorily cleared up by the discovery of more perfect specimens.

Ctenodus cristatus, Agassiz. (Ref., Poiss. Foss., vol. iii., pl. 19, fig. 16.)—The teeth known by this name are of two kinds, mandibular and palatal. The palatal teeth are composed of a thin plate somewhat elliptical in form, varying from two inches to two and a half inches in length, and from an inch and a half to an inch and three quarters in breadth. The upper surface of the plate is concave, and is covered with a number of close-set transverse ridges, the grooves between the ridges becoming deeper as they approach the outer margin of the tooth. The summit of the ridges is "studded from end to end with closely-

arranged tubercles." This arrangement is, however, subject to variation. In some of our specimens the tubercles cover only the ridges in the outer half of the palate: in all of them the tubercles are largest on the outer margin. (See plate, fig. 2.) The mandibular teeth (see plate, fig. 1) are narrower than the palatal. Our largest specimen measures three inches in length, and an inch and a half in breadth. The upper surface of this tooth is convex and covered with eighteen transverse ridges. The summit of the ridges is studded "from end to end" with tubercles: those on the outer border being conical, the rest becoming more elongated posteriorly. Like the palatal teeth, the number and arrangement of the tubercles is not constant. In some specimens there are only five tubercles on the anterior half of the tooth. At present we are unable to determine whether these variations are of specific importance. In addition to a large series of detached bones of Ctenodi which have been collected in various parts of the coalfield, we have one or two specimens showing a large portion of the skull. One of these displays the bones belonging to the anterior part of the head lying in their natural position, and the various bones are distinguished by well-defined sutures. A mandibular tooth two and a half inches long and one inch broad is lying apparently *in situ*. This tooth has fourteen transverse ridges studded anteriorly with tubercles. A second specimen shows several of the head bones indifferently preserved. A mandibular tooth of the same size and number of ridges as mentioned above, together with the impression of a palatal tooth, is seen lying on the same slab. Several elongated bones, which are no doubt sphenoid bones, with a wide expansion near the anterior extremity, have occurred. Two or three large, nearly circular plates, which are probably opercular plates of Ctenodi, slightly convex on the upper side, measuring six

inches in diameter, have been found, together with numerous rib-bones and other remains. Detached scales similar to those figured and described by Messrs. Hancock and Atthey (Ann. Nat. Hist. ser. 4, vol. 9) as belonging to Ctenodi have been found in the Moss coal shale and Cockshead ironstone. They measure two and a half inches in length and three inches in breadth. The border of the scale for a width of about half an inch is covered with fine striæ. The centre of the scale is also covered with striæ, much finer than those on the border. These bear a close resemblance to scales figured by Dr. Newberry under the title of Rhizodus quadratus (Geol. Surv., Ohio, p. 39, fig. 8.)

Position and locality :—Palates, Knowles, Deep mine, Chalky mine, and Bassy mine ironstones, Fenton and Longton ; Brown mine, Silverdale. Scales (?) Moss coal shale, Fenton ; Cockshead ironstone, Adderley Green.

Ctenodus tuberculatus, Atthey. (Ref., Ann. and Mag. Nat. Hist., ser. 4, 1868.)—Several specimens which we refer to this species have occurred. The most prominent features, as described by Mr. Atthey, are as follows (*Ibid*, p. 88) : "Tooth, plate-like, thick, with an irregular ovate outline, two and three quarter inches long, an inch and six-eighths broad, the narrow end posterior ; the inner margin gibbous or angulated in the centre ; the outer margin a little convex ; the surface is slightly convex, and is furnished with twelve or thirteen deep, sharp, parallel, approximate ridges, which are strongly tuberculated towards the outer margin, and divided by narrow, deep, angulated grooves."

Position and locality :—Knowles ironstone shale, Fenton.

Ctenodus ellipticus, Atthey. (Ref., Ann. and Mag. Nat

Hist., ser. 4, 1868.)—One imperfect specimen of this species has been found. The tooth plate is very thin and much flattened; the upper surface covered with five transverse, angular, smooth ridges.

Position and locality :—Moss coal shale, Fenton.

Ctenodus imbricatus, Atthey. (Ref., Ann. and Mag. Nat. Hist., ser. 4., vol. for 1868.)—Several specimens of this rare form have occurred. "The tooth is depressed, very thick, hollow or slightly concave; it has six ridges or plaits, which enlarge rapidly towards the outer margin; they are strong, smooth, and somewhat distant from each other." (*Ibid.*)

Position and locality :—Gubbin ironstone, Shelton; Brown mine, Silverdale; Deep mine ironstone, Longton.

Ctenodus obliquus, Atthey. (Ref., Ann. and Mag. Nat. Hist., ser. 4, vol. for 1868.)—This species is very rare. Two specimens of palatal teeth have been found; they are lanceolate in form; the upper surface is covered with six or seven transverse ridges.

Position and locality :—Rare; Deep mine ironstone, Longton.

Reptilia.

Animals of this class are rare in these coal-measures. So far as we yet know they are confined to two or three beds in the upper division of the Pottery coalfield. Good specimens of jaws, teeth, vertebræ, and rib bones, together with portions of the skull of several individuals, have been

found, but no complete specimen has yet occurred. These remains have been collected chiefly from the Rag mine and Chalky mine ironstones at Fenton. The occurrence of Labyrinthodonta in beds highly charged with fish remains is of great interest. No doubt these creatures lived in the marshes or amongst the rank and luxuriant foliage which grew upon the banks of the rivers or seas of that period. That they made frequent visits, no doubt in quest of prey, to the waters in which fishes lived, is evident from the fact that in the beds above-mentioned remains of both fishes and reptiles are found commingled. The discovery of reptilia in this coalfield is not of recent date. A single tooth of one of these creatures is figured in Mr. Garner's "Natural History of Staffordshire." (Plate E, fig. 13.) Within the past ten or twelve years specimens representing three or four additional genera have been found. These, in consequence of the limited state of our knowledge, at that time, of animals of this class were thought to be the remains of Rhizodus and other sauroid fishes. It is only within the past few years that their true character has become known.

Labyrinthodonta.

Euglypta, Miall.

Anthracosaurus Russelli, Huxley. (Ref., Quar. Jour. Geol. Soc., vol. xix., p. 56.)

Position and locality:—Rag mine ironstone, Fenton; Ash coal shales, Fenton. Lower jaw and upper portion of the skull have occurred.

MALACOCYLA, MIALL.

Loxomma Allmani, Huxley. (Ref., Quart. Jour. Geol. Soc., vol. xviii., p. 291.)

Position and locality:—Chalky mine and Rag mine ironstones, Fenton. Lower jaw, cranial shield, teeth, and vertebræ.

ATHROÖDONTA, MIALL.

Pteroplax cornuta, Hancock and Atthey. (Ref., Ann. Nat. Hist., vol. i., ser. 4, pl. xiv.)

Position and locality:—Wood's mine shale, Longton; large teeth in the Gubbin ironstone, Shelton (a tooth from this locality is figured in Nat. Hist. County Stafford, pl. E, fig. 18).

Pholiderpeton, Huxley. (Ref., Quart. Jour. Geol. Soc., vol. xxv.)

Position and locality:—Vertebræ and ribs in the Rag mine ironstone, Fenton.

NECTRIDEA, MIALL.

Urocordylus Wandesfordii (?), Huxley. (Ref., Trans. Roy. Irish Acad., 1867.)

Position and locality:—One small specimen of this curious Amphibian has been obtained: the under side of the head is tolerably well preserved, but the bones of the trunk and limbs are much distorted. Ash coal shale, Longton.

EXPLANATION OF THE PLATE.

FIG.

1.—Mandibular tooth of Ctenodus cristatus, Ag.
2.—Palatal tooth of Ctenodus cristatus, Ag.
3.—Fin spine of Gyracanthus formosus, Ag.
4.—Scale of Rhizodus (Holoptychius) Garneri, Murch.
5.—Tooth of Pteroplax cornuta, Hancock and Atthey.
6.—Scale of Rhomboptychius, Hux.
7.—Tooth of Strepsodus sauroides, Hux.
8.—Tooth of Janassa (Climaxodus, McCoy) linguæformis, Atthey.
9.—Tooth of Pleuracanthus (Diplodus, Ag.) gibbosus
10.—Tooth of Megalichthys Hibberti, Ag.
11.—Tooth of Helodus simplex, Ag.
12.—Tooth of Ctenoptychius apicalis, Ag.
13.—Tooth of Pleurodus Rankinii, Ag.
14.—Scale of Megalichthys Hibberti, Ag.
15.—Tooth of Ctenacanthus hybodoides, Eg.

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MACRO-LEPIDOPTERA

TAKEN AND OBSERVED IN NORTH STAFFORDSHIRE BY MEMBERS OF THE CLUB.

COMPILED BY THOMAS W. DALTRY, M.A., F.L.S.

NOTE.—In the case of rare insects, or such as have been only occasionally observed in this district, the initials of the finder are appended:—

THOMAS W. DALTRY, . . .	T.W.D.
E. EARL, ...	E.E.
ALFRED SMITH, ...	A.S.
L. H. JAHN, ...	L.H.J.
F. W. DUTTON, ...	F.W.D.

DIURNI (BUTTERFLIES).

LEUCOPHASIA :—*Sinapis*, one at Swinnerton in 1869 (H. Till, A.S.)

PIERIS :—*Brassicæ*, *Rapæ*, *Napi*, common everywhere.

ANTHOCARIS :—*Cardamines*, common in meadows.

GONEPTERYX :—*Rhamni*, Craddock's Moss, Madeley, &c., not abundant.

COLIAS :—*Edusa*, Madeley, Leycett, Astbury, Whitmore, (T.W.D., A.S.), six or seven in 1869.

ARGYNNIS :—*Euphrosyne*, Burnt Woods, Swynnerton.—*Silene*, Burnt Woods, plentiful, Swynnerton.

MELITÆA :—*Artemis*, Craddock's Moss (T.W.D.), plentiful in 1866.

VANESSA :—*C. Album*, Swynnerton, Burnt Woods (A.S.), in 1866.—*Urticæ.*—*Polychloros*, Madeley (T.W.D.), one pupa in 1873.—*Antiopa*, Eccleshall, Swynnerton, Swithamley, Cannock Chase, 1873. This very rare insect in this country was taken by Mr. Dutton at Eccleshall, and seen at the other places.—*Io*, *Atalanta*, common.—*Cardui*, Madeley, &c., rare in this district.

SATYRUS :—*Megæra*, widely spread, but not common.—*Janira*, *Tithonus*, abundant.—*Hyperanthus*, Burnt Woods, Madeley, plentiful but local.

CHORTOBIUS :—*Davus*, Chorlton Moss, &c., abundant on mosses.—*Pamphilus*, everywhere.

THECLA :—*Rubi*, Maer, Craddock's Moss, &c., local.—*Quercus*, Swynnerton, plentiful.

POLYOMMATOS :—*Phlœas*, abundant.

LYCÆNA :—*Agestis*, Dovedale, plentiful (T.W.D.)—*Alexis*, common.—*Alsus*, Dovedale.—*Argiolus*, Maer, Burnt Woods.

THANAOS :—*Tages*, Leycett, on coal pit lows, &c.

HESPERIA :—*Sylvanus*, Burnt Woods, plentiful but local.—*Linea*, Madeley, railway banks (T.W.D.)

NOCTURNI.

SMERINTHUS :—*Ocellatus*, larvæ plentiful on sallows.—*Populi*, pupæ at roots of poplars.

ACHERONTIA :—*Atropos*, Death's Head, one imago in Vicarage Garden at Madeley (T.W.D.), larvæ on potatoes.

SPHINX :—*Ligustri*, larvæ on privet near Stoke (L.H.J.)

CHÆROCAMPA :—*Porcellus*, rare, one imago (E.E.)—*Elpenor*,

larvæ on Epilobium Hirsutum and Galium Palustre, general.

MACROGLOSSA :—*Stellatarum*, Humming Bird Hawk Moth, not uncommon in some seasons.—*Bombyliformis*, Craddock's Moss, not uncommon, flies at flowers of Pedicularis sylvestris (A.S., &c.)

SESIA :—*Tipuliformis*, general in gardens, larvæ in stems of the red currant.—*Spheciformis*, this rare clear-wing has twice been taken by A.S., viz., a pair together at Burnt Woods, and a third at Craddock's Moss; larvæ in alder.—*Bembeciformis*, Stoke and Newcastle (L.H.J., E.E.)—*Apiformis*, near Stoke (L.H.J.)

COSSUS :—*Ligniperda*, Goat Moth, near Eccleshall, larvæ in willows (F.W.D.)

HEPIALUS :—*Hectus*, Gold Swift, plentiful where the common brake grows, Swynnerton, Burnt Woods.—*Lupulinus*, very common in grass fields.—*Sylvinus*, Newcastle, Madeley (E.E., T.W.D.), common in some seasons.—*Velleda*, Northern Swift, general.—*Humuli*, Ghost, common in mowing grass.

PROCRIS :—*Statices*, mowing grass, in a field near Walton's Wood, Madeley, plentiful (T.W.D.)

ZYGÆNA :—*Filipendulæ*, Six-spot Burnett, railway cutting at Madeley (T.W.D.)

NOLA :—*Cucullatella*, one at Madeley (T.W.D.), larvæ on sloe.—*Cristulalis*, one seen at Burnt Woods in 1873 (T.W.D.)

NUDARIA :—*Mundana*, one at Madeley (T.W.D.)

LITHOSIA :—*Mesomella*, Four-spot Footman, not uncommon at Burnt Woods and Swynnerton.

EUTHEMONIA :—*Russula*, Chorlton Moss, &c.

CHELONIA :—*Plantaginis*, Swynnerton.—*Caja*, everywhere.

ARCTIA :—*Fuliginosa*, Craddock's Moss, Swynnerton (A.S.), scarce.—*Lubricipeda*, *Menthastri*, the Ermines, abundant everywhere.

LIPARIS :—*Auriflua*, Gold-tail, common.

ORGYIA :—*Pudibunda*, Pale Tussock, common in woods.—*Antiqua*, Vapourer, common in woods and gardens.

DEMAS :—*Coryli*, Nut Tussock, Swynnerton, larvæ on birch and oak (A.S.), scarce.

PÆCILOCAMPA :—*Populi*, December Moth, an imago at Swynnerton (T.W.D.), a larva at Chorlton Moss on alder (T.W.D.), scarce in this district.

BOMBYX :—*Rubi*, Fox, abundant, larvæ hybernate full-fed.—*Quercus*, Oak Egger, everywhere.

ODONESTIS :—*Potatoria*, Drinker, everywhere, larvæ on cocks-foot grass (Dactylis glomerata).

SATURNIA :—*Carpini*, Emperor, not uncommon, larvæ on heath, sallow, bramble.

GEOMETRÆ.

OURAPTERYX :—*Sambucata*, Swallow Tail, common, larvæ taken on ivy (T.W.D.), hybernates.

EPIONE :—*Apiciaria*, not uncommon near Stoke (L.H.J.), Madeley (T.W.D.)

RUMIA :—*Cratægata*, Sulphur, abundant in lanes, &c.

VENILIA :—*Maculata*, one at Dovedale (T.W.D.)

ANGERONA :—*Prunaria*, Orange Moth, abundant at Swynnerton.

METROCAMPA :—*Margaritata*, Light Emerald, plentiful at Swynnerton, &c.

ELLOPIA :—*Fasciaria*, Maer, Swynnerton.

EURYMENE :—*Dolobraria*, Scorch-wing, Swynnerton, Burnt Woods, Madeley, &c.

PERICALLIA :—*Syringaria*, Lilac Beauty, one near Eccleshall (F.W.D.)

SELENIA :—*Illunaria*, common Thorn, Swynnerton (A.S.), Willowbridge (T.W.D.)—*Lunaria*, Lunar Thorn, Burnt Woods (A.S.), Madeley (T.W.D.)

ODONTOPERA :—*Bidentata,* abundant.

CROCALLIS :—*Elinguaria,* generally distributed.

ENNOMOS :—*Tiliaria,* Canary Thorn, larvæ on alders at Chorlton Moss (T.W.D.), near Stoke (L.H.J.)—*Erosaria,* Swynnerton and Burnt Woods, on oak (A.S.)—*Angularia,* Burnt Woods, &c.

HIMERA :—*Pennaria,* Feathered Thorn, plentiful.

PHIGALIA :—*Pilosaria,* plentifully distributed.

AMPHYDASIS :—*Prodromaria,* Oak Beauty, Trentham, Swynnerton.—*Betularia,* Pepper, abundant.

BOARMIA :—*Repandata,* Swynnerton, &c., abundant.

TEPHROSIA :—*Crepuscularia, Biundularia,* Engrails, abundant at Swynnerton, Maer, Madeley, &c.

GEOMETRA :—*Papilionaria,* Large Emerald, not uncommon in perfect and larval stage, Swynnerton, Chorlton Moss, &c., larvæ on birch and alder (T.W.D.)

IODIS :—*Lactearia,* very abundant on birch.

PHORODESMA :—*Bajularia,* a single specimen at Swynnerton (A.S.)

EPHYRA :—*Porata,* not common, Swynnerton, (T.W.D.)—*Punctaria,* abundant in woods.—*Pendularia,* Burnt Woods, not uncommon.

ASTHENA :—*Luteata,* Burnt Woods, not uncommon.—*Candidata,* Walton's Wood, Swynnerton, &c., common.—*Sylvata,* on alder, near Rushton, three in 1873 (T.W.D.)

EUPISTERIA :—*Heparata,* not uncommon at Burnt Woods, larvæ on alder.

ACIDALIA :—*Scutulata,* Madeley, &c., general.—*Bisetata,* Madeley, &c., general.—*Remutata,* common in woods.—*Fumata,* common at Swynnerton, a northern species.—*Imitaria,* a widely-dispersed species, Madeley, &c.—*Aversata,* common everywhere.—*Emarginata,* not common, one at Madeley (T.W.D.)

CABERA :—*Pusaria,* abundant on birch.—*Exanthemaria,* general, on sallow.

MACARIA :—*Notata,* Peacock Moth, Swynnerton, Burnt Woods.—*Liturata,* Swynnerton, Maer, &c., on Scotch fir.

HALIA :—*Wavaria,* V moth, common in gardens, on gooseberry.

PANAGRA :—*Petraria,* common about patches of the brake fern.

NUMERIA :—*Pulveraria,* common in woods and hedges.

SCODIONA :—*Belgiaria,* taken once at Whitmore (A.S.), on ling.

FIDONIA :—*Atomaria,* very abundant on heaths.—*Piniaria,* very abundant on Scotch fir.

ASPILATES :—*Strigilaria,* abundant on heaths.

ABRAXAS :—*Grossularia,* Magpie, very common in gardens, &c.—*Ulmata,* Clouded Magpie, Madeley, &c., general on wych elm.

LIGDIA :—*Adustata,* Scorched Carpet, one at Madeley (T.W.D.)

LOMASPILIS :—*Marginata,* Clouded Border, common, on sallow.

HYBERNIA :—*Rupicapraria,* common on hedges in February, after dark.—*Leucophearia,* common in February in woods.—*Aurantiaria,* common in October and November, Swynnerton.—*Progemmaria,* common in hedges in March.—*Defoliaria,* common in woods in November.

ANISOPTERYX :—*Æscularia,* common in March on trunks of trees.

CHEIMATOBIA :—*Brumata,* common on hedges in November and December.—*Boreata,* Swynnerton, on birch (T.W.D.)

OPORABIA :—*Dilutata,* common everywhere in October.

LARENTIA :—*Didymata,* common on hedge banks.—*Multistrigaria,* not common, Swynnerton (T.W.D.)—*Pectinitaria,* common in woods.

EMMELESIA :—*Alchemillata,* not common, Whitmore (T.W.D.), Stoke (L.H.J.)—*Albulata,* meadows near Leycett (T.W.D.), in seed pods of Rhinanthus Crista-galli.—*Decolorata,* general, in seed pods of Lychnis dioica.

EUPITHECIA :—*Pulchellata,* common in flowers of foxglove.—*Subfulvata,* one at Loggerheads (T.W.D.)—*Castigata,* common.—*Lariciata,* pine woods, Maer (E.E.)—*Indigata,* pine woods, common.—*Nanata,* not uncommon, on heaths.—*Assimilata,* one at Maer Heath (T.W.D.)—*Vulgata,* common everywhere.—*Tenuiata,* several at Swynnerton (T.W.D.)—*Abbreviata,* not uncommon at Swynnerton in May.—*Exiguata,* (T.W.D.)—*Pumilata,* not uncommon, and widely dispersed.—*Debiliata,* the Bilberry Pug, plentiful at Swynnerton—probably this is its head-quarters—on bilberry.

LOPHOBORA :—*Lobulata,* Swynnerton, in April.

THERA :—*Variata,* very common in pine woods.—*Firmata,* not uncommon in pine woods, comes out later than Variata, and its larva is readily distinguished from that of Variata by its red head.

YPSIPETES :—*Impluviata,* May Highflier, not uncommon, in May, on alder.—*Elutata,* very abundant everywhere.

MELANTHIA :—*Rubiginata,* Wrinehill Wood, &c. (T.W.D.)—*Ocellata,* not uncommon, on galium.—*Albicillata,* not uncommon, on bramble.

MELANIPPE :—*Hastata,* common in some years, in birch woods.—*Procellata,* one at Trentham (L.H.J.), on Clematis vitalba.—*Rivata,* Burnt Woods, &c.—*Subtristata, Montanata, Fluctuata,* very common everywhere.

ANTICLEA :—*Badiata*, common, on dog rose.—*Derivata*, not common, Walton's Wood (T.W.D.), Craddock's Moss (A.S.), on dog rose.

COREMIA :—*Munitata*, a northern insect, one at Trentham, (A.S.)—*Propugnata*, *Ferrugata*, *Unidentaria*, all common.

CAMPTOGRAMMA :—*Bilineata*, Yellow Shell, abundant.—*Fluviata*, one near Stoke (L.H.J.)

PHIBALAPTERYX :—*Lignata*, near Stoke (L.H.J.)

SCOTOSIA :—*Dubitata*, not common, Swynnerton, Madeley, &c.—*Undulata*, Swynnerton, common in some seasons.

CIDARIA :—*Corylata*, abundant in woods.—*Russata*, pine woods, Maer, &c.—*Immanata*, abundant in hedges, woods, &c.—*Suffumata*, not common, but widely spread.—*Ribesaria*, near Stoke (L.H.J.), on currant.—*Testata*, the Chevron, common, on sallow.—*Populata*, common, on bilberry.—*Fulvata*, not uncommon, on dog rose.—*Pyraliata*, Madeley (T.W.D.), on galium.

EUBOLIA :—*Cervinaria*, Madeley, on mallow.—*Mensuraria*, abundant.—*Palumbaria*, common in heathy places.—*Bipunctaria*, common at Dovedale (T.W.D.)

CARSIA :—*Imbutata*, common on mosses, on cranberry.

ANAITIS :—*Plagiata*, not common, Swynnerton (A.S.), Madeley (T.W.D.)

CHESIAS :—*Spartiata*, Chorlton, common on broom.—*Obliquaria*, a few at Chorlton (T.W.D.), on broom.

TANAGRA :—*Chærophyllata*, Chimney Sweep, meadow near Leycett.

DREPANULÆ.

PLATYPTERYX :—*Lacertula*, common, on birch.—*Falcula*, Pebble Hook Tip, on alder and birch.

CILIX :—*Spinula,* common in 1874, widely dispersed.

PSEUDO-BOMBYCES.

DICRANURA :—*Bicuspis,* Alder Kitten, one at Chorlton Moss, by the Rev. J. W. Daltry, in 1870, a rare moth. —*Furcula,* Barlaston and Burnt Woods (A.S.)—*Bifida,* near Stoke, on poplars (L.H.J.)—*Vinula,* Puss Moth, common.

PETASIA :—*Bucephala,* Buff Tip, very common.

NOTODONTA :—*Camelina,* Cockscomb Prominent, common. —*Dictæa,* rare, Whitmore, Etruria (A.S.), Stoke (L.H.J.)—*Dictæoides,* larvæ not rare on birch.—*Dromedarius,* larvæ common on birch and alder.—*Ziczac,* larvæ, scarce, on sallow.—*Trepida,* Swynnerton (E.E., T.W.D.)—*Chaonia,* rare, one at Swynnerton (A.S.)—*Dodonæa,* not common, Swynnerton (A.S.)

DILOBA :—*Cæruleocephala,* common, larvæ on pear, white thorn, &c.

NOCTUÆ.

THYATIRA :—*Derasa,* Etruria (A.S.), Madeley (T.W.D.), Stoke (L.H.J.), not common.—*Batis,* Swynnerton, Burnt Woods (A.S.), Stoke (L.H.J.), not common.

CYMATOPHORA :—*Duplaris,* one bred (A.S.)—*Diluta,* common, Burnt Woods, Swynnerton.—*Flavicornis,* not uncommon, Swynnerton, Craddock's Moss.—*Ridens,* scarce, Swynnerton (T.W.D.), Trentham (L.H.J.)

BRYOPHILA :—*Perla,* common, on walls.

ACRONYCTA :—*Psi,* Dagger, common.—*Leporina,* Miller, not uncommon, on birch.—*Megacephala,* not uncommon, on poplar.—*Alni,* three larvæ of this scarce

moth were taken in 1873 by the Rev. J. W. Daltry in Walton's Wood, Madeley; one near Newcastle in 1873 (E.E.)—*Rumicis,* common.—*Menyanthidis,* not common, Craddock's Moss, Chorlton Moss.

LEUCANIA :—*Lithargyria,* common.—*Comma,* common.—*Impura,* Madeley.—*Pallens,* the Common Wainscoat.

NONAGRIA :—*Fulva,* one at Chorlton Moss (T.W.D.)—*Typhæ,* larvæ common in bullrushes.

GORTYNA :—*Flavago,* larvæ in thistle stems.

HYDRÆCIA :—*Nicticans,* Whitmore (T.W.D.), not common. —*Micacea,* Swynnerton, Madeley.

AXYLIA :—*Putris,* not uncommon.

XYLOPHASIA :—*Rurea, Lithoxylea, Polyodon,* all common.

DIPTERYGIA :—*Pinastri,* Swynnerton (A.S.), Madeley (T.W.D.), on Scotch fir.

APOROPHYLA :—*Australis,* one at light near Stoke (L.H.J.)

HELIOPHOBUS :—*Popularis,* not rare in some seasons, Stoke (L.H.J.), Madeley, in 1872 (T.W.D.)

CHARÆAS :—*Graminis,* not uncommon.

LUPERINA :—*Testacea,* common in 1868.

MAMESTRA :—*Anceps,* common.—*Brassicæ,* common in gardens, on cabbage.

APAMEA :—*Basilinea,* common.—*Oculea,* general.

MIANA :—*Strigilis,* abundant at sugar.—*Fasciuncula,* not uncommon, Madeley.—*Literosa,* one at Madeley (T.W.D.)—*Arcuosa,* not uncommon, on Aira cæspitosa.

CELÆNA :—*Haworthii,* Wybunbury Moss, one in 1872 (T.W.D.)

GRAMMESIA :—*Trilinea,* not common.

CARADRINA :—*Morpheus,* on flowers in the dusk.—*Blanda,* Madeley.—*Cubicularis,* general.

RUSINA :—*Tenebrosa,* in woods, at sugar in June.

AGROTIS :—*Suffusa,* widely dispersed, but not common.—*Saucia,* Swynnerton, rare.—*Segetum,* Turnip Moth,

larvæ in turnips, common.—*Exclamationis*, Heart and Dart, generally common.—*Corticea*, Swynnerton, not common.—*Porphyrea*, Swynnerton, Burnt Woods, on heath.

TRIPHÆNA :—*Janthina*, not common, Madeley, Craddock's Moss, &c.—*Fimbria*, not common, Swynnerton, &c.—*Orbona*, common in some seasons.—*Pronuba*, very abundant and general.

NOCTUA :—*Glareosa*, not common, Hay Sprink, Madeley; Burnt Woods.—*Augur*, common.—*Plecta*, general.—*Brunnea*, common.—*Festiva*, everywhere.—*Dahlii*, not uncommon in 1868, not seen since.—*Rubi*, not seen since 1868 (T.W.D.)—*Umbrosa*, not seen since 1868 (T.W.D.)—*Baja*, always common.—*Neglecta*, Swynnerton, Burnt Woods, often plentiful.—*Xanthographa*, common in gardens, &c.

TRACHEA :—*Piniperda*, common in all pine woods.

TÆNIOCAMPA :—*Gothica*, *Rubricosa*, *Instabilis*, common at sallow bloom, in the evening.—*Populeti*, rare, one at Madeley in 1874 (T.W.D.)—*Stabilis*, common at sallow bloom.—*Gracilis*, not common, Madeley (T.W.D.)—*Miniosa*, not common, Swynnerton (T.W.D., A.S.)—*Munda*, not uncommon, generally dispersed.—*Cruda*, common, at sallows.

ORTHOSIA :—*Lota*, not common, Swynnerton, Madeley.—*Macilenta*, Hay Sprink, Madeley, (T.W.D.)

ANCHOCELIS :—*Rufina*, *Litura*, common at Swynnerton.

CERASTIS :—*Vaccinii*, common everywhere.—*Spadicea*, not common, in gardens, &c.

SCOPELOSOMA :—*Satellitia*, common everywhere.

XANTHIA :—*Citrago*, larva at Trentham (L.H.J.)—*Cerago*, *Silago*, not common, but generally dispersed.—*Ferruginea*, common everywhere.

CIRRÆDIA :—*Xerampelina*, rare, a larva at Madeley (T.W.D.) several imagos near Stoke (L.H.J.)

TETHEA :—*Subtusa*, larvæ on poplar, near Stoke (L.H.J.), an imago at Madeley (T.W.D.)

COSMIA :—*Trapezina*, abundant.

DIANTHÆCIA :—*Capsincola*, common in capsules of Lychnis dioica.

HECATERA :—*Serena*, rare, one at sugar at Swynnerton in 1874 (T.W.D.)

POLIA :—*Chi*, generally common.

MISELIA :—*Oxyacanthæ*, common, on white thorn.

AGRIOPIS :—*Aprilina*, common, on oak.

PHLOGOPHORA :—*Meticulosa*, common, in woods and gardens.

EUPLEXIA :—*Lucipara*, common, in gardens, &c.

APLECTA :—*Herbida*, rare, one at Swynnerton (T.W.D.), at Burnt Woods (A.S.)--*Nebulosa*, abundant in woods.—*Tincta*, not uncommon, at Swynnerton and Burnt Woods.

HADENA :—*Protea*, common, on trunks of trees in September.—*Glauca*, not uncommon.—*Dentina*, not common.—*Oleracea*, common.—*Pisi*, common in some seasons, on broom, sallow, &c.—*Thalassina*, common.

XYLOCAMPA :—*Lithoriza*, general, on trunks of trees in March.

CLOANTHA :—*Solidaginis*, common in most seasons, in pine woods.

CALOCAMPA :—*Vetusta*, rare, one at Swynnerton in 1873 (T.W.D.)—*Exoleta*, common and general.

CUCULLIA :—*Chamomillæ*, rare, one at Heleigh Castle in 1872 (T.W.D.)—*Umbratica*, common, at flowers in gardens at dusk.

ANARTA :—*Myrtilli*, common on heaths.

HELIODES :—*Arbuti*, not common, Leycett (A.S.), near Swynnerton (T.W.D.)

BREPHOS :—*Parthenias,* plentiful, at Swynnerton in April, on birch.

ABROSTOLA :—*Urticæ,* not common, on nettles and hop.—*Triplasia,* common, on nettles.

PLUSIA :—*Chrysitis,* common, at flowers at dusk in July.—*Festucæ,* rare, one near Eccleshall (F.W.D.)—*Iota, V-Aureum,* common, at flowers at dusk at Midsummer.—*Gamma,* common, everywhere.—*Interrogationis,* rare, taken at Whitmore some years ago (A.S.)

GONOPTERA :—*Libatrix,* Herald, common, on sallow.

AMPHIPYRA :—*Pyramidea,* Copper Underwing, not uncommon at Swynnerton.—*Tragopogonis,* Mouse, common.

MANIA :—*Typica,* very common.—*Maura,* Old Lady, common, on sallow.

EUCLIDIA :—*Mi,* Mother Shipton, common at Craddock's Moss.—*Glyphica,* Burnet, rare, railway cutting near Madeley (T.W.D.)

PHYTOMETRA :—*Ænea,* common at Craddock's Moss.

DELTOIDES.

HYPENA :—*Proboscidalis,* common everywhere, on nettle.—*Crassalis,* common, at Swynnerton, on heath.

HERMINIA :—*Grisealis,* not uncommon, Walton's Wood, Madeley.

PYRALIDES.

AGLOSSA :—*Pinguinalis,* general, Madeley (T.W.D.)

PYRAUSTA :—*Punicealis,* one at Dovedale in 1874 (T.W.D.)—*Purpuralis,* not common, Craddock's Moss, &c.

HERBULA :—*Cespitalis,* Weaver Hills (T.W.D.)

CATACLYSTA :—*Lemnalis,* common on ponds, on duckweed.

PARAPONYX :—*Stratiotalis,* not common, one at Madeley (T.W.D., A.S.), on Stratiotes, Callitriche, &c.

HYDROCAMPA :—*Nymphœalis,* Brown China Mark, common on ponds, on Potamogeton.—*Stagnalis,* Beautiful China Mark, on a pond at Madeley.

BOTYS :—*Verticalis,* one at Little Madeley in 1870 (T.W.D.) —*Fuscalis,* common in meadows, Leycett, &c., on seeds of Rhinanthus Crista-Galli.—*Urticalis,* common on nettles.

EBULEA :—*Crocealis,* occurs only near Grafton's Wood, Madeley, on Inula dysenterica (T.W.D.)—*Sambucalis,* not uncommon (T.W.D., A.S.), on elder.

PIONEA :—*Forficalis,* common in gardens.

SCOPULA :—*Lutealis,* very common, on coltsfoot.—*Olivalis,* common.

SCOPARIA :—*Ambigualis,* common on tree trunks in woods, &c.—*Pyralalis,* common, at Dovedale, 1874 (T.W.D.) *Truncicolalis,* common in woods on tree trunks.

CRAMBITES.

CRAMBUS :—*Pratellus,* common in grass fields in June.— *Pascuellus,* common.—*Margaritellus,* common on mosses, Chorlton, Wybunbury, &c.—*Perlellus,* two near Swynnerton in 1874 (T.W.D.)—*Warringtonellus,* Chorlton, Craddock's, and Wybunbury Mosses.— *Tristellus,* common.—*Culmellus,* most abundant, on grass, in June and July.—*Hortuellus,* abundant.

PHYCIS :—*Betulella,* Swynnerton, on birch.—*Carbonariella,* on heaths.

RHODOPHÆA :—*Tumidella,* common at Swynnerton, on oak.

NOTE.—To the above list must be added Lobulata Viretata, a specimen of which was taken last summer at Burnt Woods (T.W.D.)

Comparative Table of North Staffordshire Lepidoptera.

	British.	North Staffordshire.
Diurni	65	33
Nocturni	113	39
Geometræ	282	126
Drepanulæ	6	3
Pseudo-Bombyces	27	14
Noctuæ	318	131
Deltoides	15	3
Pyralides	76	19
Crambites	81	11
Total	983	379

So that out of 983 species that occur in the British Isles, 379 have been taken in nine years in North Staffordshire by four or five members of the Club. Of Diurni, or Butterflies, it will be observed that we have quite half.

THE END.

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